FOREST RESEARCH INFORMATION PAPER NO. 173

Succession Pathway Tool 1.0:

User's Guide

Ministry of Natural Resources

Natural. Valued. Protected.

Ontario

Forest Research Information Paper No. 173

Succession Pathway Tool 1.0:

User's Guide

by

Marc Ouellette and Michael Drescher

2010

Ontario Forest Research Institute
Ontario Ministry of Natural Resources
1235 Queen Street East
Sault Ste. Marie, Ontario
Canada P6A 2E5

APPLIED RESEARCH AND DEVELOPMENT • ONTARIO MINISTRY OF NATURAL RESOURCES

Library and Archives Canada Cataloguing in Publication Data

Ouellette, Marc R.
Succession Pathway Tool 1.0 : user's guide [electronic resource]

(Forest research information paper ; no. 173)
Includes bibliographical references.
Electronic monograph in PDF format.
Issued also in printed form.
ISBN 978-1-4435-1894-9

1. Succession Pathway Tool (Computer file). 2. Forest succession—Computer programs.
3. Forest succession—Computer simulation. 4. Forest dynamics—Computer simulation.
5. Forest regeneration—Computer simulation. I. Drescher, M. II. Ontario Forest Research Institute. III. Title. IV.
Series: Forest research information paper (Online) ; no. 173.

SD409 O94 2010 634.9 '560113 C2010-964001-2

Printed in Ontario, Canada

Single copies of this publication are available from:

Ontario Forest Research Institute
Ministry of Natural Resources
1235 Queen Street East
Sault Ste. Marie, ON
Canada P6A 2E5

Cette publication hautement spécialisée *Succession Pathway Tool 1.0: User's Guide* n'est disponible qu'en anglais en vertu du Règlement 411/97, qui en exempte l'application de la Loi sur les services en français. Pour obtenir de l'aide en français, veuillez communiquer avec le ministère de Richesses naturelles au (705) 946-2981.

Abstract

Forest succession knowledge is used extensively to support forest management decisions. However, that knowledge is often implicit and thus not documented or transferable. The Succession Pathway Tool (SPT) is a software package for Windows designed to help users of succession knowledge make their knowledge of forest succession explicit, visualize it using networks, and explore its emerging properties using stochastic aspatial simulations. It also provides a means to document and share forest succession knowledge. Here we introduce prospective users to the software tool and provide step-by-step instructions and a brief tutorial with examples of how to apply the tool. We also provide information about how to export documented succession knowledge for use in other tools, including the Boreal Forest Landscape Dynamics Simulator (BFOLDS).

Resume

La connaissance de la succession en forêt boréale est utilisée couramment pour appuyer les décisions en matière de gestion des forêts. Par contre, cette connaissance est souvent implicite, donc ni documentée, ni transférable. L'outil de trajectoire de succession (Succession Pathway Tool - SPT) est un progiciel Windows conçu pour aider les utilisateurs de la connaissance de la succession à rendre explicite leur connaissance de la succession en forêt boréale, à la visualiser grâce à des réseaux, et à explorer ses propriétés naissantes au moyen d'applications aspatiales stochastiques. Il offre également un moyen de documenter et de diffuser la connaissance de la succession en forêt. Dans la présente, nous initions les utilisateurs éventuels à l'outil logiciel et mettons à leur disposition des instructions étape par étape et un bref tutoriel avec des exemples du mode d'utilisation de l'outil. Nous fournissons également de l'information à propos des méthodes d'exportation de la connaissance documentée de la succession en vue de son utilisation dans d'autres outils, comme le simulateur de la dynamique des paysages de la forêt boréale (BFOLDS).

Acknowledgements

We are indebted to Ajith Perera for his extensive support without which this tool and guide would not have been developed. We also thank Phil Comeau and Rob Arnup for their helpful comments on the beta version of this software tool and the draft user's guide. Finally, we are grateful to Lisa Buse for assistance in the development/testing of the tool and for editing this guide.

Contents

1.0 Introduction

Forest resource managers require clear goals for future forest states, specific knowledge of forest succession, and an understanding of how to direct forests towards desired future states. Increasingly, the forest management planning process involves projecting current forest resource inventories into the future to assess the outcomes of alternative management scenarios (e.g., Shifley *et al.* 2000). Such projections may be relatively easy over short periods and small areas. However, forest management criteria have evolved to include ever larger areas and longer time scales.

Currently, projections of forest change are often made for many decades or even centuries into the future and for very large landscapes. The forest succession knowledge needed to make such large-scale projections is complex. It should include all possible forest cover types that could exist on the landscape, consider all major developmental stages of forests following disturbance and succession, and include all interactions among forest cover types in their various developmental stages.

While such knowledge may exist, it is often fragmented, that is, dispersed among many sources and consisting of varied, sometimes disparate information. As well much of the knowledge is implicit, i.e., not documented or formalized and thus not available for general use. Furthermore, users of forest succession knowledge may be confident about the successional relationships among certain forest cover types but unsure about others (e.g., Drescher et al. 2006, Drescher et al. 2008). While it may be possible to fill these knowledge gaps with contributions from other sources or other knowledge users, often these unknown succession relationships initially remain unspecified. Such unspecified relationships may result in varying levels of confidence about successional processes over time: Knowledge users may be clear about successional processes at short to intermediate time scales, but less sure about those at longer time scales. This is particularly true when many forest cover types can interact at various successional stages.

To enable its use in quantitative tools such as decision support systems or simulation models (e.g., USDA 1996; MSRM 2004), such forest succession knowledge needs to be explicit, that is, it needs to be expressed in a quantitative and coherent manner. The Succession Pathway Tool (SPT) was developed to aid users of forest succession knowledge to explicitly express their knowledge in a quantitative and coherent manner and to understand the long-term consequences of their statements about short to intermediate term forest succession. To do this, two different views of forest succession are built into the tool – one that addresses the individual relationships between forest cover types and another that addresses the communal relationships among all forest cover types in a network of relationships. The longer-term consequences of these statements about forest succession knowledge are expressed using aspatial simulations of forest dynamics that are derived from the user's forest succession knowledge expressions. The results of these simulations can be used to confirm expectations about general forest dynamics and to help identify and correct misrepresentations of forest succession knowledge. Overall, visual exploration of forest succession, as made possible by SPT, can facilitate a more complete understanding of forest succession in support of large-scale forest resource projections (Drescher and Perera 2010a, b).

1.1. What is the *Succession Pathway Tool?*

The Succession Pathway Tool is a simple software application designed to help the user make their knowledge of forest succession explicit, visualize it, and explore the emerging properties stemming from the specified successional relationships among individual forest cover types.

To increase its general applicability, SPT was designed as a generic tool that can be adapted to the user's needs. The user explicitly defines forest cover types, determines their interactions through natural succession or post-disturbance establishment, and can stratify their knowledge based on geography or environmental factors. The tool also allows the user to specify levels of uncertainty for individual forest cover types and successional relationships. This added information can be especially valuable when the forest succession knowledge is used by others, for example, for highlighting areas of uncertainty when applying the knowledge or identifying where further research is warranted.

The tool includes functions to visualize forest succession knowledge. These functions increase the efficiency of compiling forest succession knowledge over conventional tabular formats. As well, the visualization function improves knowledge communication and review: visualizing forest succession knowledge as networks facilitates understanding of the higher-level interactions among all forest cover types, while the lower-level visualizations provide detailed information about successional relationships between individual forest cover types in an accessible format.

Using SPT, simple aspatial simulations of forest dynamics resulting from the specified forest successional relationships are possible. This function makes SPT an exploratory tool that can help users to investigate their knowledge and uncover potential inaccuracies in their knowledge expressions. After correcting such inaccuracies, the confirmed knowledge can be applied in forest resource planning tools.

In addition to its use as a generic tool, SPT can be used in combination with the Boreal Forest Landscape Dynamics Simulator (BFOLDS, Perera et al. 2008), which is used to simulates forest landscape change over large areas and long periods. Specifically, SPT can be used to formulate forest succession knowledge for use in BFOLDS[1].

1.2. Why use the *Succession Pathway Tool?*

Uses for SPT are manifold. Here we give two examples – one for a potential use by a forest management practitioner and another for use by a forestry scientist:

- A forest management practitioner may need to project future forest states based on knowledge of forest succession for a certain area (OMNR 2004). Before employing advanced forest dynamics simulation models that may require considerable time investment, the practitioner may want to confirm that formal expressions of that forest succession knowledge produce the expected forest dynamics. With SPT, that knowledge of forest succession can be expressed in a simple and formalized way and the tool's aspatial simulation function can help to rapidly assess the forest dynamics that emerge from those knowledge expressions. If the simulated forest dynamics differ from

[1] *Note to BFOLDS users*: Before using the Succession Pathway Tool, see notes in Appendix 1.

expectations, the formalized knowledge expressions can be revisited, investigated for potential inaccuracies, and corrected. Once formalized correctly, those knowledge expressions can be exported from the tool for use in more advanced applications.

- A forestry scientist may want to investigate expert knowledge of forest succession for a certain forest landscape (Drescher et al. 2006, Drescher et al. 2008). This expert knowledge, however, may not yet have been expressed formally and is therefore not amenable to quantitative investigation. The scientist may therefore decide to hold an expert knowledge elicitation workshop in which they ask experts to express their knowledge of forest succession in simple, transparent, and quantitative terms. In this case, the tool can be used by experts to express their knowledge of forest succession. Once the experts have formalized their knowledge, it can be displayed, investigated, and stored. If required the scientist can easily retrieve the stored expert knowledge for future applications or further analysis.

Another application of SPT is for formulating forest succession knowledge for use in other analyses and/or modelling tools. One such example is BFOLDS (Perera et al. 2008): The large and complex matrices used to formalize forest succession processes in BFOLDS may result in logical errors and incorrect parameterization. Once introduced into the matrices, such errors may be difficult to recognize during visual inspection of the matrices or investigation of simulation results. The visualization procedures and aspatial simulation function in SPT make it relatively easy to identify such errors. Once identified, these errors can be corrected immediately and conveniently exported in a format that is compatible with BFOLDS requirements. Using SPT as a front-end application for BFOLDS helps to ensure that the forest succession knowledge used in the model is correctly formulated. It also increases the efficiency of the overall process of entering succession knowledge.

Generally speaking, SPT can help users of forest succession knowledge to:

Formalize forest succession knowledge: SPT helps users to express their knowledge of forest succession in a simple and formalized way, by defining forest cover types and quantifying their successional relationships. After formalization, this knowledge may be stored and easily retrieved for future use.

Visualize forest succession knowledge: SPT helps users to visualize their knowledge of successional relationships between forest cover types through the use of graphic interfaces. In this way, users can easily express their knowledge and/or compare it with other users.

Explore forest succession knowledge: SPT helps users to investigate the consequences of expressions of their forest succession knowledge through simple aspatial simulations. This may help users to identify and correct potential inaccuracies in their knowledge expressions or investigate the complex, long-term forest dynamics that may occur in large forest landscapes.

1.3. What to know before using the *Succession Pathway Tool?*

It is assumed that users of SPT are well-acquainted with the concept of forest succession. SPT is not intended as a tool to teach users about the processes underlying forest succession or about the factors affecting forest succession.

To use SPT properly and interpret the results correctly, users should be aware of the basic premises and assumptions of this tool: it was designed with a specific perspective of forests and their dynamics. SPT assumes that forests consist of relatively homogenous, spatial units that can be classified by their species composition into discrete, non-overlapping forest cover types. The size of these spatial units could range from an individual tree to a forest stand, though these decisions depend on the operational criteria used to delineate units.

Spatial interactions among units are not accounted for in SPT. This is not to say that in reality forested units do not interact, but SPT is a simple tool to formalize and explore forest succession knowledge and is not intended to replace complex, spatially explicit forest simulation models.

Forested units can remain in the original forest cover type or they may succeed from one forest cover type into another through natural succession or disturbance (Figure 1). Natural successional changes may require a certain amount of time, while changes following disturbance are almost instantaneous and do not require time. In both cases, changes occur with a certain probability that depends on the forest cover types and for successional changes also on forest age. To configure SPT, the user must know or assume the required information about forest cover type, time (i.e., forest age) of successional changes, and probabilities of those changes.

Finally, forest cover type changes via natural succession or disturbance may depend on environmental factors, such as climate or soil type. Such factors can be defined in SPT in a hierarchical way (for example, soils nested within climate). Since this information must be supplied by the user, to use the tool appropriately they require a thorough understanding of successional processes.

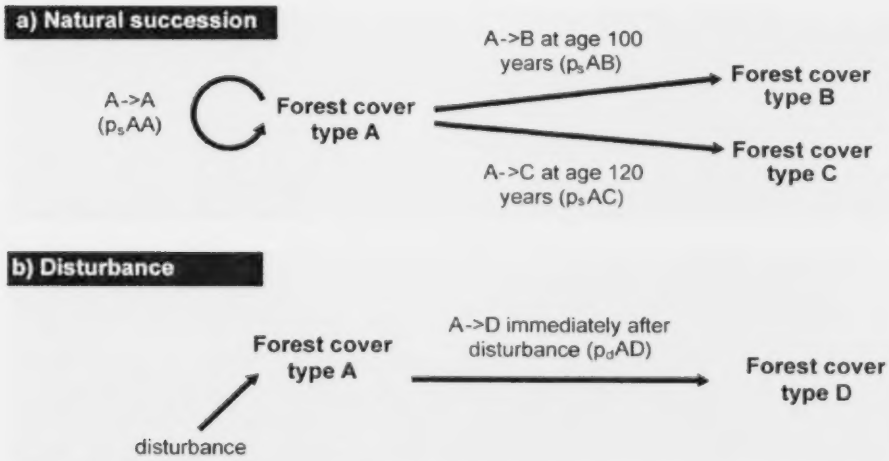


Figure 1. *Illustration of forest cover type changes in SPT. a) An area of forest can remain in the same forest cover type or succeed to another forest cover type (natural succession). This change occurs with a given probability (P_s) and only after the forest reaches a certain age. b) An area of forest can change to another forest cover type after a disturbance destroys the existing forest and a new forest establishes. This change occurs immediately after the disturbance with a given probability (P_d).*

1.4. Who would be interested in using the *Succession Pathway Tool?*

SPT was developed primarily for users of forest succession knowledge. This includes forest managers who work at the forest unit level or at larger spatial scales. However, policymakers and other decision makers may also be interested in using the tool because it can help them understand the characteristics of the knowledge used by, for example, forest managers to make projections of future forest states. Users of SPT need basic computer literacy, including the ability to prepare and import data. Interpretation of results generated with the tool does not require advanced understanding of simulation models, but does require a basic understanding of the premises and assumptions used in such models.

As well, researchers who may be interested in gathering knowledge of forest succession from various audiences in a standardized, formal manner may be interested in this tool. And it may be useful for researchers interested in a convenient way to capture their own knowledge for application in other tools. Furthermore, the tool can be used to demonstrate the principles of forest resource modelling to forest ecological and management audiences.

Users of the forest landscape simulation model BFOLDS may also find this tool helpful. To run simulations with BFOLDS, forest succession knowledge must first be formalized in stochastic matrices. These matrices are normally compiled outside of the model. This can be a tedious process and logical errors and inaccurate parameterizations can occur. The visualization functions and aspatial simulation in SPT help to assure that forest succession knowledge is formalized correctly, and the export function produces matrices that can be read directly by BFOLDS. Whether BFOLDS is used for forest management applications, forest landscape research, or for educational purposes, SPT can help to make its use more efficient.

1.5. Terms and their use in this guide and the user interface

Descriptions of terms as they are used in this guide and in SPT are provided in the table below. Appropriate use of the tool presumes an understanding of the terms as described.

Term	Description	Additional tool-specific information
Aspatial simulation	Aspatial simulation is a function in SPT that generates a visual display of the number of forest units in each forest cover type as well as the number of successional changes between forest cover types.	Aspatial simulations can be run after at least 1 network is made and can be started using the *Aspatial Simulation* button or *Aspatial Simulation* on the menu bar under *View*.
Cascading graph	A cascading graph illustrates forest succession in an entire succession pathway network. It begins with all the forest cover types in a network and continues for a user specified number of simulation years.	Cascading graph will become visible after the aspatial simulation is completed.
Complexity	Complexity is a measure of the user's perception of the complexity of the forest change (natural succession or disturbance) process as expressed in a given forest succession pathway. Complexity is related to stochastic knowledge uncertainty (see also Confidence).	A value of 5 indicates low complexity and a value of 1 indicates high complexity.
Confidence	Confidence is a measure of the user's confidence that the forest succession pathway they created accurately represents the forest change process (natural succession or disturbance) Confidence is related to uncertainty due to lack of knowledge (see also Complexity).	A value of 5 indicates high confidence and a value of 1 indicates low confidence.
Forest cover type	A forest cover type describes the primary forest vegetation at any given point and may change due to natural succession or disturbance. A forest cover type could be defined based on a certain species or a species group that describes a particular stage of succession.	Forest cover types are used to create succession pathways among one another and are represented in the network window as nodes.
Link	A link indicates the direction(s) of forest cover type change between two nodes in a network. Links represent succession pathways.	In the network window of the software tool, links are shown as arrows between forest cover type nodes.
Maximum age	Maximum age is the maximum age that a forest cover type can reach before it undergoes succession.	During an aspatial simulation, if maximum age is reached in the absence of succession, forest cover age will be reset to the minimum age.
Minimum age	Minimum age is the age of the new forest cover type following a succession step, which is 1 for post-disturbance establishment or >1 for natural succession.	If minimum age exceeds the age of the current forest cover, forest cover age is used.
Natural succession	Natural succession refers to the process by which one forest cover type is replaced by another forest cover type over time.	
Network	A network illustrates the relationship between forest cover types in a succession pathway network.	A network is shown as a series of squares (nodes) and pathways (links).
Node	A node represents a forest cover type.	In the network window of the software tool, a node is shown as a square with rounded corners.
Probability	Probability is a number, between 0 and 1, expressing the likelihood of an event, where 1 indicates that it occurs with absolute certainty and 0 indicates that it will not occur.	Probability is assigned to a forest cover type change.

Post-disturbance establishment	Post-disturbance establishment refers to the process by which forest cover is completely destroyed by a disturbance and then replaced.	
Succession pathway	A succession pathway is a succession trajectory that includes timing and probability. For example, "*forest cover A* transitions to *forest cover B* at 120 years with a probability of 0.9".	One or many succession pathways form a succession pathway network. Each link in the network window represents one succession pathway.
Succession pathway file	A succession pathway file is a file used by SPT that contains succession pathway networks for either natural succession or post-disturbance establishment. It also contains information about the related forest cover types and strata. A succession pathway file can contain many succession pathway networks (Figure 2).	
Succession pathway network	A succession pathway network consists of one or more succession pathways. Each succession network differs because each is created using a unique combination of strata.	Succession pathway networks are displayed in the application window. Only 1 network is visible at a time. The tabs at the bottom of the network window allow user to switch among networks.
Self-replacement	Self-replacement refers to the process in which a forested area does not undergo succession but remains in the current forest cover type.	Self-replacement is represented by a link from a node to that same node.
Stratum	Strata are geographic or environmental variables that affect forest succession or can be used to differentiate among locality. Possible strata include climate, soil information such as moisture, or any other type of information that differentiates one area from another.	Strata are optional and can be used to differentiate among succession networks. They are entered into the tool in hierarchical order, from most to least important (stratum 1 to 5, respectively). For a succession pathway file, up to five optional strata can be defined.
Time step	The time step is the interval at which succession occurs, which results in one forest cover type being replaced by another.	Time steps can be 5-, 10-, or 20-year intervals for natural succession. Using a 20-year time step, forest cover could succeed at ages 20, 40, 60, 80, and so on. By default, the time step for post-disturbance establishment is 1 year.

Figure 2. *The relationship among a succession pathway file, succession pathway networks, and succession pathways in SPT.*

1.6. *Succession Pathway Tool structure*

An overview of the structure of SPT showing the major steps involved in its use is provided in Figure 3. The section of the user's guide to refer to at each step is also indicated. For software installation instructions, see Appendix 1.

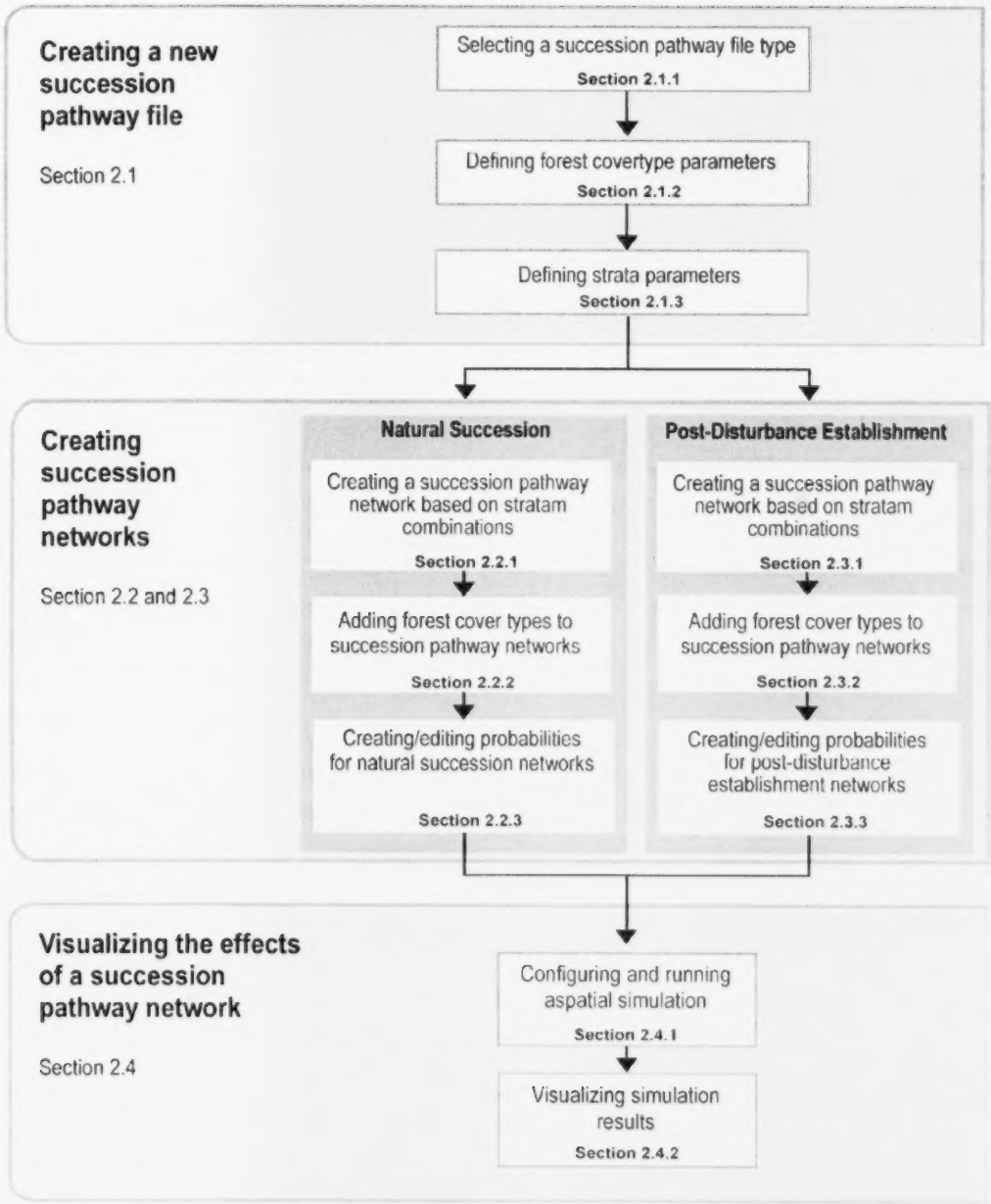


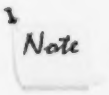
Figure 3. *Overall structure of the Succession Pathway Tool, indicating the section of the user's guide to refer to at each step.*

2.0 Using the *Succession Pathway Tool*

The Succession Pathway tool (SPT) guides the user through the process of creating succession pathway networks and visualizing those networks using aspatial simulation. In this section, we describe how the software works and explain the available user options. Each subsection begins with a general description of a specific function in the tool followed by instructions. The overall process involves:

- Defining forest cover types and strata
- Creating succession pathway networks
- Adding succession pathways with probabilities to those networks
- Using aspatial simulations and cascading graphs to view changes in succession pathways over the longer term.

As well, users can document their confidence in and the complexity of the succession pathways they develop.



Before using this software tool, the user is encouraged to read the introduction to the guide to ensure they understand the tool's intent and are familiar with the terminology.

Some basics

In SPT, information is stored in a file referred to as a succession pathway file. This file contains all of the information about forest cover types and strata entered by the user as well as the succession pathway networks defined by the user with their respective succession pathways (see Figure 2).

Before using the tool, it is important to understand the distinction between a succession *pathway* and a succession *pathway network*:

- An individual ***pathway*** documents the probability of succession between two forest cover types for a specific combination of strata.
- Each ***network*** includes all the pathways for a specific combination of strata. This can include one pathway describing transitions between two forest cover types or many pathways describing transitions between all available forest cover types.

Main window

The main window of the tool is shown below. Users are encouraged to familiarize themselves with the menu bar options and icons in the tool's main window to make it easier to follow the instructions provided in subsequent sections.

Toolbar buttons under menu bar are:

- File/New (New succession pathway file)
- File/Save (Save succession pathway file)
- File/Open (Open succession pathway file)
- File/Print (Print network window)
- File/Export as Image (Export network as image)
- Edit/File Settings (View succession pathway file settings)
- View/Aspatial Simulation (Start aspatial simulation)

Icons at the bottom left of window are:

- Network/New (New succession pathway network)
- Network/Copy (Copy succession pathway network)
- Network/Delete (Delete succession pathway network)
- Network/Information (View strata information)

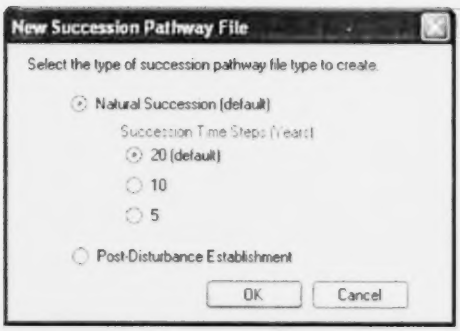
Note *Common application functions, such as print, preview, export, copy, and paste, are included in the succession pathway tool and are accessible from the menus or toolbar. These common functions work the same way as in other Windows applications.*

2.1 Creating Succession Pathway Files

To create a new succession pathway file, open the Succession Pathway Tool and under *File* on the menu bar select *New,* or select *New* button on the toolbar.

2.1.1 Selecting a succession pathway file type

In the *New Succession Pathway File* window, select the type of succession pathway file to create.



The options available are:

- ***Natural succession***: Change in forest cover type occurs at defined intervals over time in the absence of stand-replacing disturbance. The time step (or succession interval) options are 5, 10, and 20 years.
- ***Post-disturbance establishment***: Change in forest cover type occurs within 1 year following a stand-replacing disturbance such as fire.

The default setting for a new succession pathway file is natural succession with a 20-year time step.

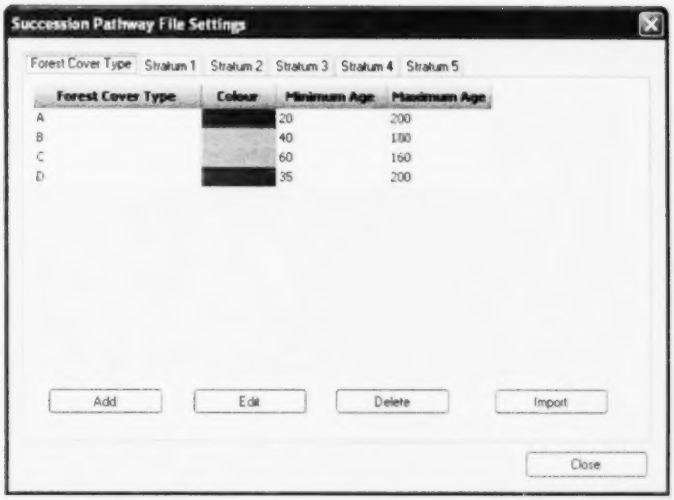
New succession pathway files must be configured before use. In the *Succession Pathway File Settings* window, a series of tabs are provided that allow the user to view and modify the forest cover types and stratum parameters:

- *Forest Cover Type* tab: Used to define forest cover types needed to create succession pathways within a succession pathway file.
- *Strata* tabs: Used to define up to 5 optional strata that can be used to differentiate succession pathways based on environmental or other factors.

2.1.1 Defining forest cover type parameters

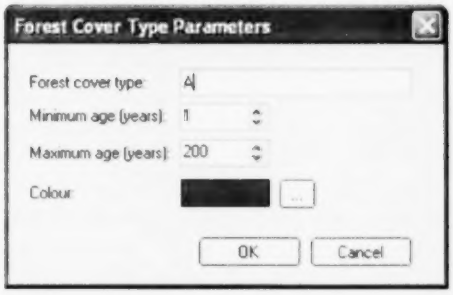
Under the Forest Cover Type tab, the user can add or modify existing forest cover type information for the pathways in the active succession pathway file.

The *Add* button allows the user to enter a new forest cover type and define the associated parameters.



After the *Add* button is selected, the *Forest Cover Type Parameter* window is displayed allowing the user to enter the following parameters:

- *Forest cover type*: A name that identifies the forest cover type; these should be unique and meaningful to the user.
- *Minimum age*: The default minimum age of the forest cover type after natural succession.
- *Maximum age*: The default maximum age that can be achieved by the forest cover type before it is reset to minimum age.
- *Colour*: The colour that will be associated with a particular forest cover type in network windows and outputs.



Note *For post-disturbance establishment succession pathway files, ages are not visible in the above window; by definition these are 1.*

To change the *Forest Cover Type* or any of the associated parameters, select *Edit* or double click the forest cover type row in the table.

To delete forest cover types from the succession pathway file, highlight the forest cover type in the table and select *Delete*.

To import user-predefined forest cover types from an ASCII file, select *Import*. Imported files must contain 1 forest cover type per line followed by a line feed.

Note *When a forest cover type is deleted, it will be removed from all networks within the succession pathway file and the probabilities assigned to it will be restored to the source forest cover type. This means that if the probability of forest cover type A going to B was 0.5 and of self-replacement was 0.5, when B is deleted, the self-replacement probability of A would increase to 1.*

2.1.2 Defining strata parameters

The *Stratum 1* through *Stratum 5* tabs allow the user to name the strata that are relevant to the succession pathway networks. Changing the text in the *Stratifying criteria* will change the text displayed on the tab. These designations will then be used for all occurrences in the software.

To add a stratum class, select *Add*.

To change information associated with a stratum, select *Edit or* double click the row in the table.

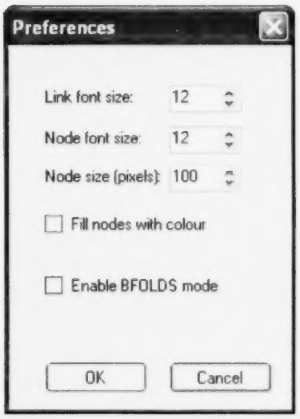
To remove a stratum from the succession pathway file, highlight the row in the table and select *Delete*.

To import user-predefined strata from an ASCII file, select *Import*. Imported files must contain 1 stratum class per line followed by a line feed.

When a stratum is deleted, networks that include that stratum class or any other strata nested below it will also be deleted from the succession pathway file. See Appendix 3 for details about strata use and hierarchy.

2.1.3 Changing preferences

The *Preferences* window allows the user to modify the way information is presented in the network window and in the *Succession Pathway File Settings* window. To access the *Preferences* window select *Preferences* under *Edit* on the menu bar.



The options available are:

- *Link font size*: Text font size associated with links among pathways and probabilities.
- *Node font size*: Text font size used for forest cover type names within nodes.
- *Node size*: Display size used for forest cover type nodes.
- *Fill nodes with colour*: If selected, network nodes will be a solid user-selected colour. If not selected, colour is applied only to the outside edge of nodes.
- *Enable BFOLDS mode*[2]: By default this mode is enabled when forest cover type and strata information are imported from a BFOLDS study. It will display a value column for forest cover types and strata tabs. This is an integer value that is used in the ASCII grids required for BFOLDS.

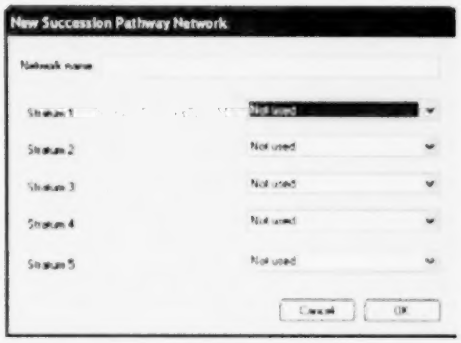
[2]Applies only if the succession pathways will be exported for use in BFOLDS (for more information see Appendix 1).

2.2 Creating Natural Succession Pathway Networks

After creating a natural succession pathway file and defining the forest cover types and strata (see section 2.1), succession pathway networks can be created.

2.2.1 Creating a succession pathway network based on stratum combinations

In the *New Succession Pathway Network* window the default settings (all strata set to *Not used*) will create a succession pathway network at the most basic level, i.e., without strata. More complicated networks can be created by defining strata.



Strata operate in a nested fashion, for example, if both stratum 1 and 2 are defined, 2 would be nested within 1. For a more detailed explanation of the application of strata in the tool, see Appendix 3. For an example of its use, see the tutorial in section 3.1.

To create a succession pathway network, select *New* from the *Network* option on the menu bar or click on the *New Network* button to display the *New Succession Pathway Network* window.

Note *Succession pathway network names and the stratum combinations within each must be unique. Higher priority strata must be defined, i.e., set to something other than "not used" before a lower priority stratum can be added to a rule set.*

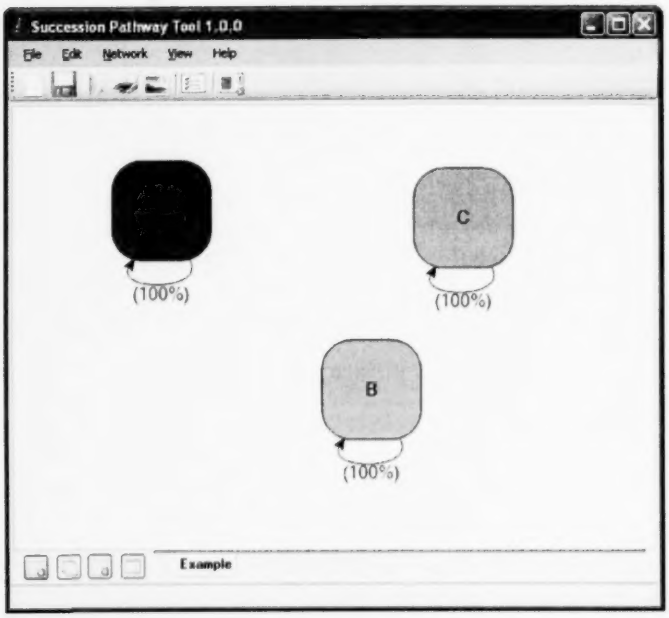
2.2.2 Adding forest cover types to succession pathway networks

Before creating succession pathways in a network, forest cover types must be added to the network window. In the network window, forest cover types are represented by square symbols called *nodes*.

To add forest cover type nodes to the network window, use the *Insert Forest Cover Type* window that displays immediately after a network is created. Select the desired forest cover types individually or use the *Select All* button to select all available forest cover types. Select *OK* to add the selected items to the network window.

Alternatively, right click anywhere in the network window to view a popup menu and select the *forest cover types* menu entry to display a list of the user-defined forest cover types (see section 2.1.3). Add forest cover types to a network by selecting them from the list or add all forest cover types using *Select All*.

Once added to a network, forest cover type nodes can be moved anywhere in the network window by clicking near their centre and dragging them to the desired location.

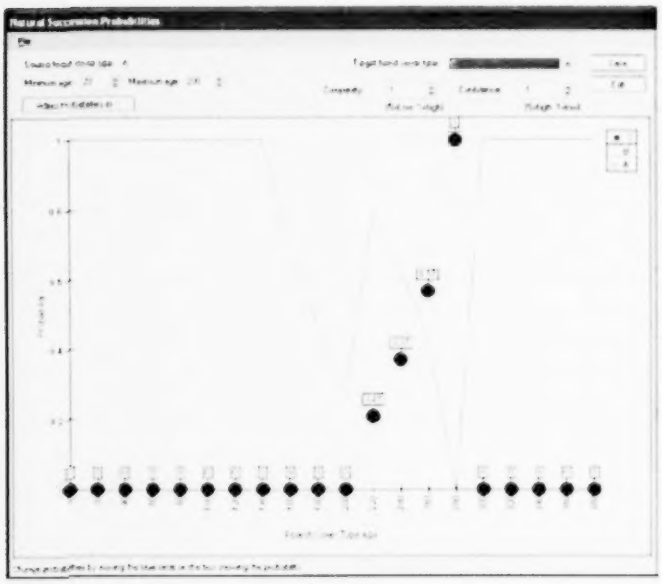


2.2.3 Creating/editing probabilities

To add natural succession pathways to a network, at least two forest cover types (or nodes) are required (see section 2.2.2).

By default, when added to a network, forest cover types are completely self-replacing. In the example shown, each node has a link indicating that 100% of this forest cover type will replace itself, i.e., a probability of self-replacement of 1.0.

To create a succession pathway with a given probability of forest cover *A* succeeding to forest cover *B*, click on the inside edge of node *A* and move the cursor to node *B* to create a *pathway (link)* between the two nodes. This link represents a succession pathway from the *source* forest cover type *A* to the *target* forest cover type *B*.



After the appropriate forest cover type nodes are linked (by repeatedly dragging the cursor between nodes), double click on the source forest cover type node to open the *Natural Succession Probabilities* window.

In this window, the user can edit the probability of succession from a source forest cover type to each target forest cover type. As these probabilities are modified, self-replacement probabilities will adjust automatically.

To adjust the succession probabilities, select and move the blue circles (or the squares showing the probability) up or down.

To change the active target forest cover type, in the drop down box at the top right of the window select an alternate *Target forest cover type*.

Note that succession probabilities must add to 1; if this is not the case an error message will display beside the *Adjust Probabilities to 1* button. The window cannot be closed until the error is resolved, either manually using the blue circles or by selecting *Adjust Probabilities to 1*.

Note

For natural succession, once canopy age reaches the first succession interval, all forest cover types are eligible to undergo succession. After that, forest cover types become eligible for succession based on the time step assumed by the user. The succession probabilities input by the user for each forest cover type will be reapplied (at 5, 10, or 20-year intervals) up to a maximum of 400 years. When a forest cover type's canopy age exceeds 400 years, the Succession Pathway Tool defaults to the probability values assigned to age 400.

An additional (optional) feature in SPT allows the user to document their confidence in the succession pathways they create as well as their views about the complexity of those pathways. To add this information, the user chooses among five levels for both confidence and complexity in the appropriate data field:

Confidence: 1=low to 5=high

Complexity: 5=low to 1=high

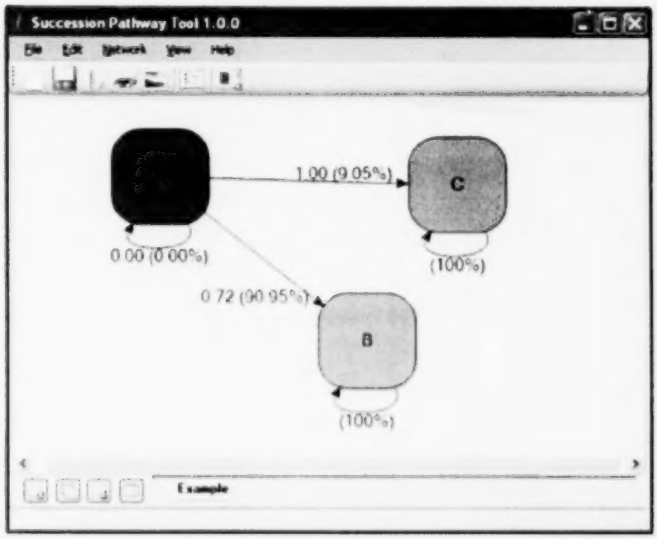
These values can be adjusted using the up and down arrows in the appropriate field for each target forest cover type.

To save the changes and exit, select *Save*.

Once the window is closed, the network will be updated to reflect the information entered in the steps described above. The self-replacement arrows are updated to show the minimum probabilities for self-replacement and the proportion of units in that forest cover type that remain for self replacement.

The pathways to other nodes are updated to show the maximum probability of the source forest cover type succeeding to a target forest cover type, again with the relevant proportions.

To change the text that appears on the link to show the probability or complexity/confidence ratings or to hide it, select the appropriate options under the *Link Visible Value* option under *View* on the menu bar. These options may be useful for printing and/or presentation purposes.



2.3 Creating Post-Disturbance Establishment Succession Pathway Networks

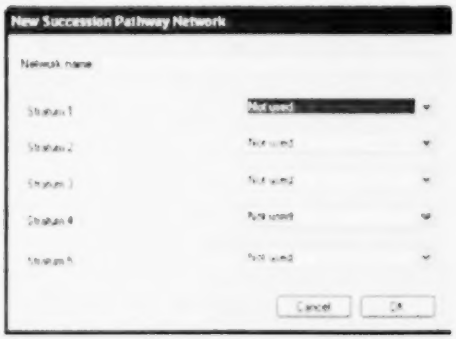
After creating a post-disturbance establishment succession pathway file and defining the forest cover types and strata (see section 2.1), succession pathway networks can be created.

2.3.1 Creating a succession pathway network based on stratum combinations

In the *New Succession Pathway Network* window the default settings (all strata set to *Not used*) will create a succession pathway network at the most basic level, i.e., without strata. More complicated networks can be created by defining strata.

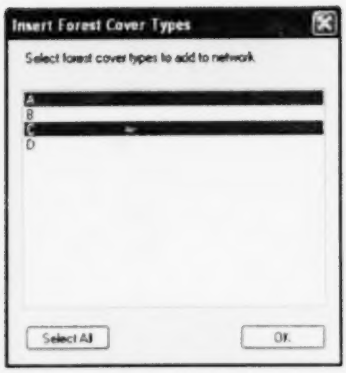
Strata operate in a nested fashion, for example, if both stratum 1 and 2 are defined, 2 would be nested within 1. For a more detailed explanation of the application of strata in the tool, see Appendix 3. For an example of its use, see the tutorial in section 3.2.

To create a succession pathway network, select *New* from the *Network* option on the menu bar or click on the *New Network* button to display the *New Succession Pathway Network* window.



Note *Succession pathway network names and the stratum combinations within each must be unique. Higher priority strata must be defined, i.e., set to something other than "not used" before a lower priority stratum can be added to a rule set.*

2.3.2 Adding forest cover types to succession pathway networks



Before creating succession pathways in a network, forest cover types must be added to the network window. In the network window, forest cover types are represented by square symbols called *nodes*.

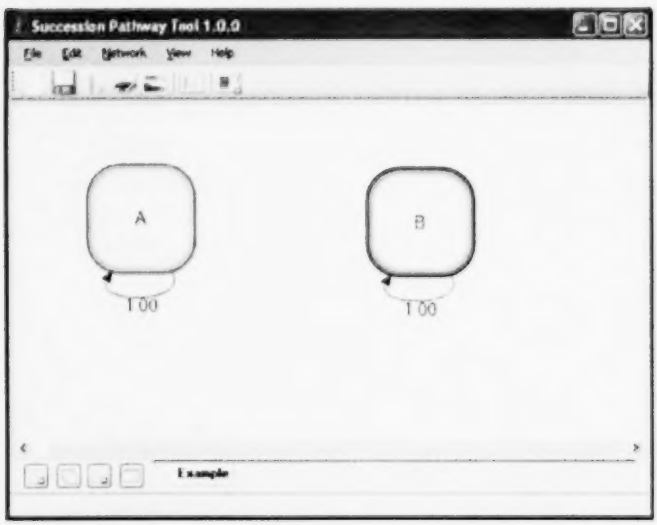
To add forest cover type nodes to the network window, use the *Insert Forest Cover Type* window that displays immediately after a network is created. Select the desired forest cover types individually or use the *Select All* button to select all available forest cover types. Select *OK* to add the selected items to the network window.

Alternatively, right click anywhere in the network window to view a popup menu and select the *forest cover types* menu entry to display a list of the user-defined forest cover types (see section 2.1.3). Add forest cover types to a network by selecting them from the list or add all forest cover types using *Select All*.

Once added to a network, forest cover type nodes can be moved anywhere in the network window by clicking near their centre and dragging them to the desired location.

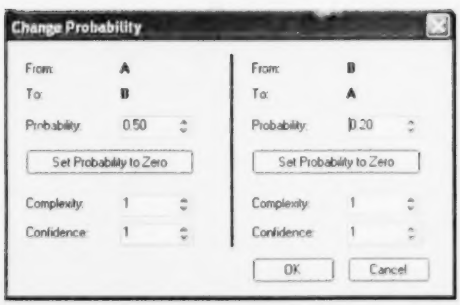
2.3.3 Creating/editing probabilities

To add post-disturbance establishment pathways to a network, at least two forest cover types (or nodes) are required (see section 2.3.2).



By default, when initially added to a network, forest cover types are completely self-replacing. In the example shown, each node has a link indicating that this forest cover type will replace itself with a probability of 1.0.

To create a succession pathway with a given probability of forest cover *A* succeeding to forest cover *B*, select the inside edge of node *A* and move the cursor to node *B* to create a *pathway (link)* between the two nodes. This link represents a succession pathway from the *source* forest cover type *A* to the *target* forest cover type *B*.



After the nodes are linked (by dragging the cursor between nodes), the *Change Probability* window displays to allow succession pathway details to be entered.

Links can be unidirectional, allowing the user to determine the probabilities at each end. In the example shown, forest cover type *A* succeeds to forest cover type *B* with a probability of 0.5 and forest cover type *B* succeeds to forest cover type *A* with a probability of 0.2.

An additional (optional) feature in SPT allows the user to document their confidence in the succession pathways they create as well as their views about the complexity of those pathways. To add this information, the user chooses among five levels for both confidence and complexity in the appropriate data field:

Confidence: 1=low to 5=high

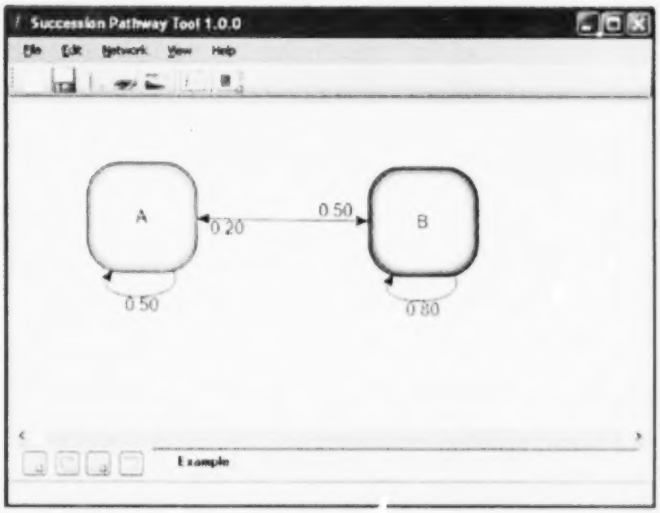
Complexity: 5=low to 1=high

These values can be adjusted using the up and down arrows in the appropriate field for each target forest cover type.

After selecting *OK*, the network window is updated to reflect the new post-disturbance establishment probabilities between nodes *A* and *B*. Note that the self-replacement probabilities of nodes *A and B* were also adjusted.

To modify existing probabilities, double click the link between the nodes to display the *Change Probability* window.

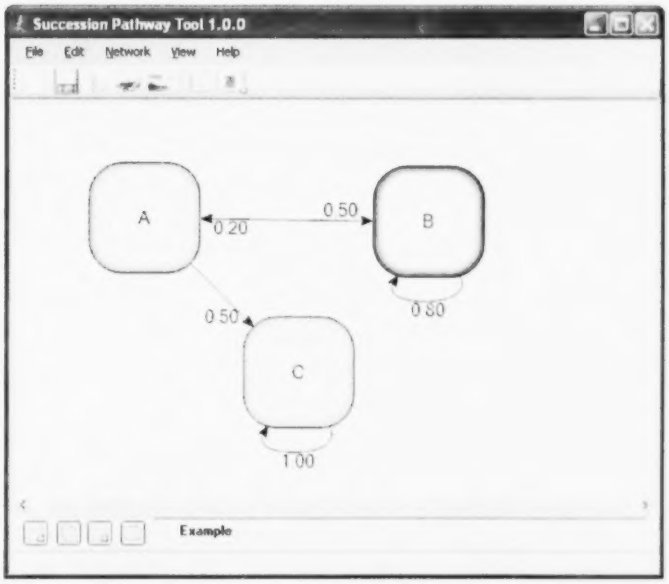
Following the same patterns as above, the user can add more nodes (forest cover types) to the network and create additional links (pathways) between nodes to add the associated probabilities.



When the probability of a forest cover type *A* transitioning to 1 or more forest cover type sums to 1.0, no self-replacement will take place, and no self-replacement arrow will be visible (see example shown).

To delete links or nodes, right click the node or the link between nodes and select *Remove*. When a node is deleted, all links going to or from it are also deleted. In the example provided if node C were deleted, the 0.5 probability assigned to it would revert to A.

To change the text that appears on the link to show the probability or complexity/confidence ratings or to hide it, select the appropriate options under the *Link Visible Value* option under *View* on the menu bar. These options may be useful for printing and/or presentation purposes.



2.4 Visualizing Succession Pathway Network Dynamics

To help the user visualize the effect of their succession pathways through time, the tool includes an aspatial simulation function.

This aspatial simulation is a very simplistic representation of forest succession. Its limitations include that:

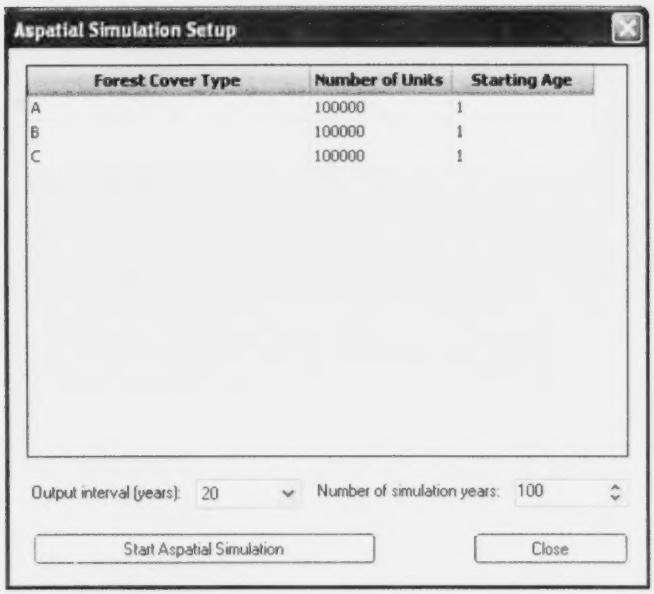
- Natural succession and post-disturbance establishment are simulated independently
- Only one network can be simulated at a time
- Forest cover type succession history is not considered, that is, if forest cover type *a* and *b* go to *c*, when *c* undergoes succession, the tool does not differentiate whether *c* came from *a* or *b*.
- Only one starting age can be specified for a forest cover type

2.4.1 Configuring and running an aspatial simulation

To run an aspatial simulation, it must first be configured by entering information in the *Aspatial Simulation Setup* window.

To configure an aspatial simulation, start the *Aspatial Simulation Setup* window by selecting the *Aspatial Simulation* button or *Aspatial Simulation* under *View* on the menu bar.

For each forest cover type enter:



- *Number of units*: The number of units that belong to a forest cover type at the start of simulation. This unit can be hectares, acres, or m^2 depending on user preference.
- *Starting age*: The age of the forest cover type at the start of the simulation. (Only relevant for natural succession.)

As well, select the *Output interval* for which to generate the cascading graph and the *Number of simulation years* to allow the simulation to run. For post-disturbance establishment simulations both these options are limited to 1.

Selecting an output interval greater than the succession time step for a particular network (see section 2.1.1) may result in some transitions not showing or results that are confusing. Optimally, the aspatial simulation output interval should be the same as or shorter than the succession time step.

Select *Start Aspatial Simulation* to run it.[3]

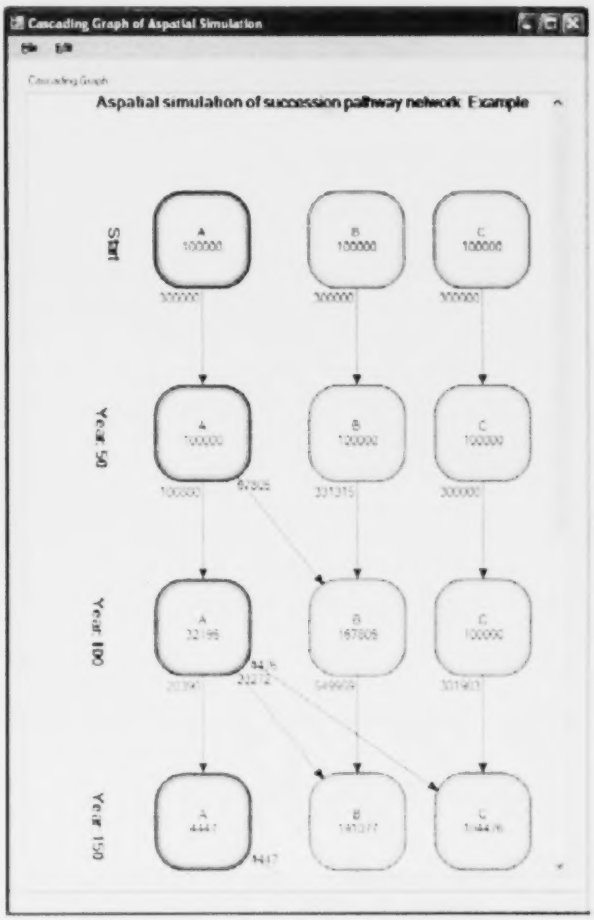
[3]*Note to BFOLDS users*: When developing succession pathways, errors can be hard to locate and solve using BFOLDS output. Two common errors are that (1) the number of units for a forest cover type decreases to a minimum or disappears completely from the landscape, and (2) a forest cover type never undergoes succession because it reaches maximum age before it has a chance to succeed to another forest cover type. Simulating succession pathway networks created for BFOLDS using the aspatial simulation option in the Succession Pathway Tool provides a simple and efficient way to find and correct such errors before running BFOLDS simulations.

2.4.2 Visualizing simulation results

When the simulation is complete, an *Aspatial Simulation Cascading Graph* will display. This graph includes the following information:

- *Number of successional changes:* Beside each arrow is a number that indicates the number of successional changes between a source forest cover type and a target forest cover type.

- *Number of units*: Within each forest cover type node is a number that indicates the number of units of that forest cover for that time step.



Note

If the values are difficult to see, select the link to display the number of transitions in the status bar.

3.0 Succession Pathway Tool Tutorials

Here we present two examples of the steps involved in using the succession pathway tool to develop (a) natural succession and (b) post-disturbance establishment succession pathways. For each step, the purpose is explained, followed by the details and associated results.

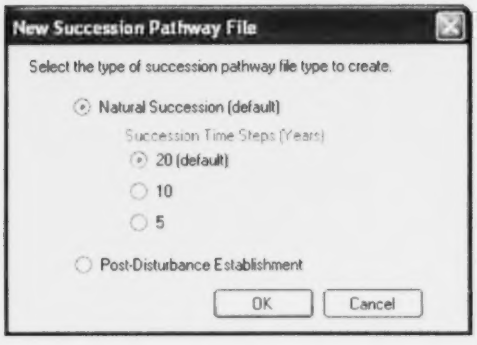
All forest cover type and strata information in these examples are fictitious.

3.1 Natural Succession Example

Here we illustrate the use of the Succession Pathway Tool (SPT) to create a succession pathway file for three natural succession pathway networks.

Step 1: Creating a Succession Pathway File and Setting up the Parameters

The process for creating a succession pathway file and setting up the forest cover type and strata parameters needed to create natural succession pathways is as follows:

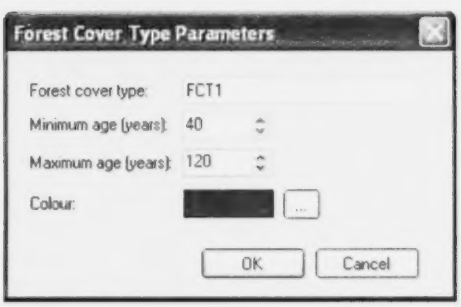


1. Start SPT.
2. Select *File, New* on the menu bar or the *New* button on the toolbar.
3. When the *New Succession Pathway File* window displays, select *OK*. Note that natural succession and 20-year time steps are the default options.

   The *Succession Pathway File Settings* window will display.
4. The next step is to add forest cover types. For these examples, five forest cover types (FCTs 1-5) will be used as shown in the table at left.

Forest Cover Type	Minimum Age	Maximum Age	Colour
FCT1	40	120	Red
FCT2	60	180	Green
FCT3	40	200	Blue
FCT4	80	180	Yellow
FCT5	30	160	Grey

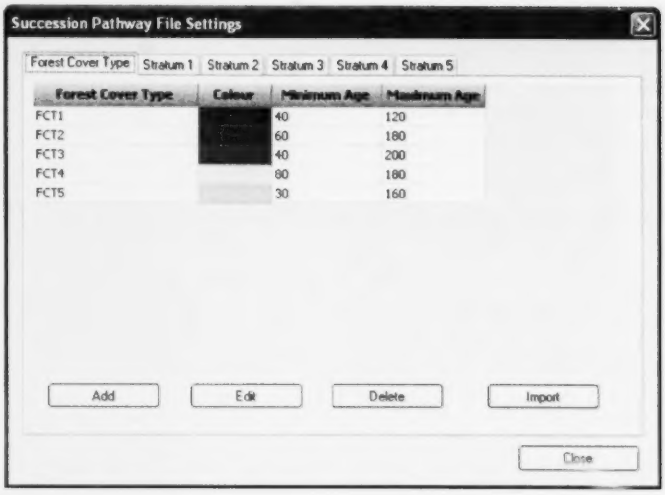
5. Select *Add* at the bottom of the window to display the *Forest Cover Type Parameters* window.
6. Enter *FCT1* in the *Forest Cover Type* field in the window.
7. Set the *Minimum age* to 40 using the up/down buttons (or typing directly in text box).
8. Set the *Maximum age* to 120 using the up/down buttons (or typing directly in text box).



9. Set the *Colour* to red using the button (or by double clicking the coloured square).
10. Select *OK* to finish adding the forest cover type parameters and close the window.

11. Enter the remaining four forest cover types and their parameters (repeat steps 5 to 10 using the ages and colours shown at right).
12. The resulting window should match the example shown.

    Alternatively, pre-defined lists of forest cover types can be imported using the *Import* option (see section 2.1.1 for details).



13. To enter the stratum information, first select the tab labelled *Stratum 1*.
14. Enter *Soil moisture* as the stratum name in the *Stratifying criteria* field.
15. Select *Add* and enter *Dry* in the popup window. Select *Add* and enter *Wet* in the popup window.

    The resulting window should match the example shown.

    Alternatively, pre-defined lists of strata can be imported using the *Import* option (see section 2.1.2 for details).

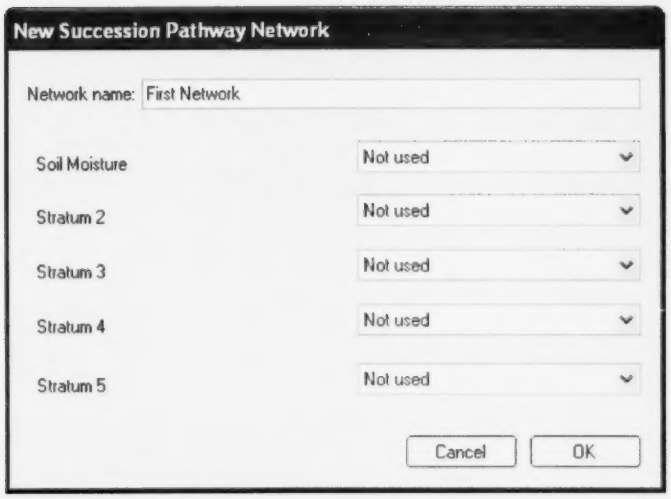
16. Select C*lose* to exit the *Succession Pathway File Settings* window and return to the main application. A prompt to save the file will display. Selecting *Yes* will display a *File Save As* window. Alternatively, the file can be saved by selecting the *Save* icon on the toolbar or selecting the *File, Save as* on the menu bar to save to a new file.

This completes the configuration of the succession pathway file, which can now be used to create natural succession pathway networks.

Note *The file containing Step 1,* Example Natural Succession Step 1 Completed.pt, *is available in the Succession Pathway Tool installation folder.*

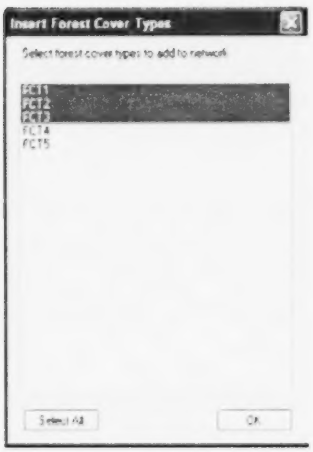
Step 2: Creating the First Succession Pathway Network

Here we outline the steps involved in creating the first succession pathway network in the succession pathway file. This succession pathway network will be created at the most basic level, that is, it will not use the stratum information.



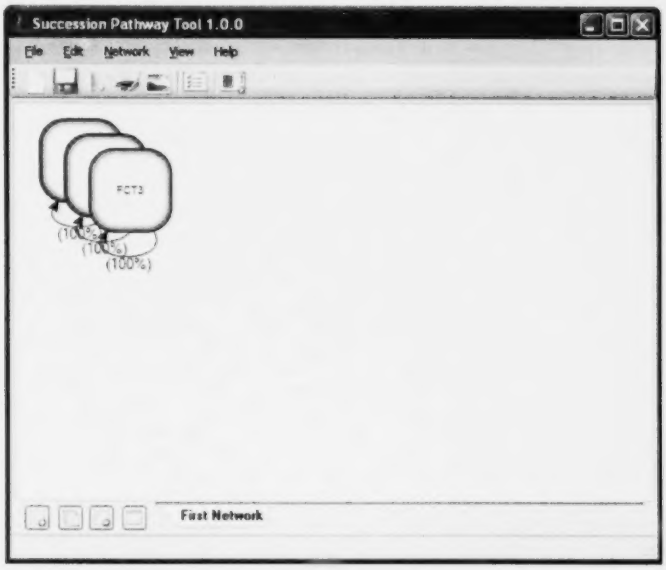
1. Select *Network/New* on the menu bar or the *New Network* button on the bottom left in the window.

2. For *Network name*, enter *First Network* and select *OK*. Since stratum information is not being used for this succession pathway network, none of the other options in this window apply.

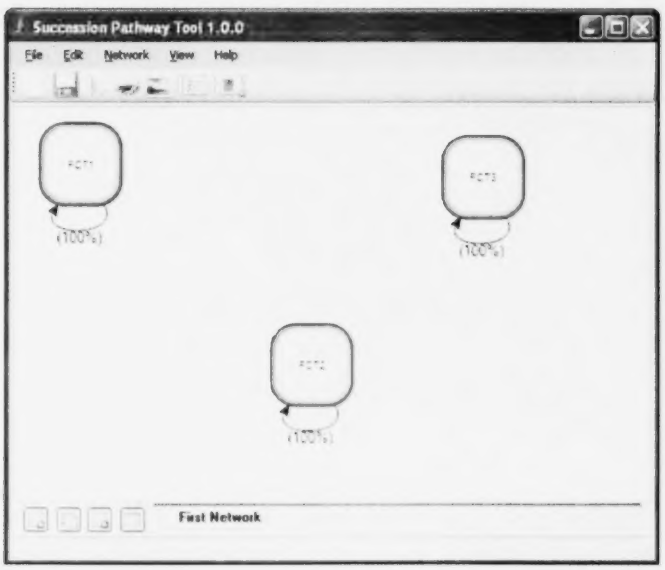


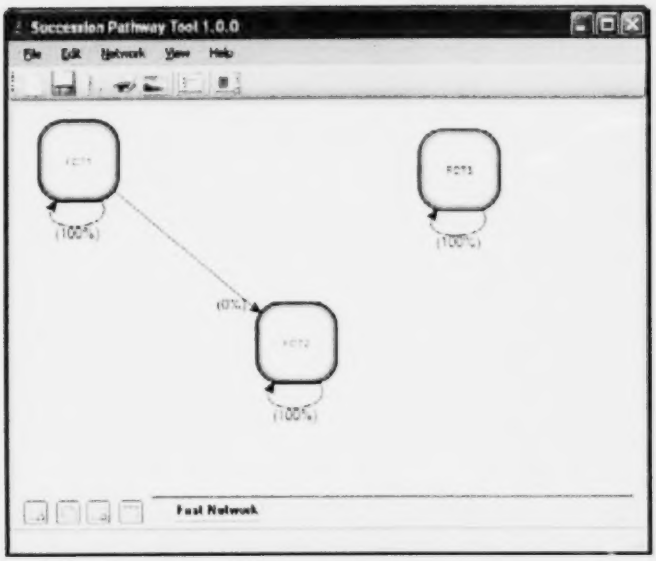
3. Selecting *OK* displays the *Insert Forest Cover Types* window. Highlight the first 3 forest cover types (FCT1, FCT2, and FCT3) in the list and select *OK*.

4. This will result in a new window that displays the selected forest cover types as a series of nodes (as shown).

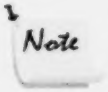


5. Select and hold the left mouse button on the middle of a node to move it to where it does not overlap with another node.

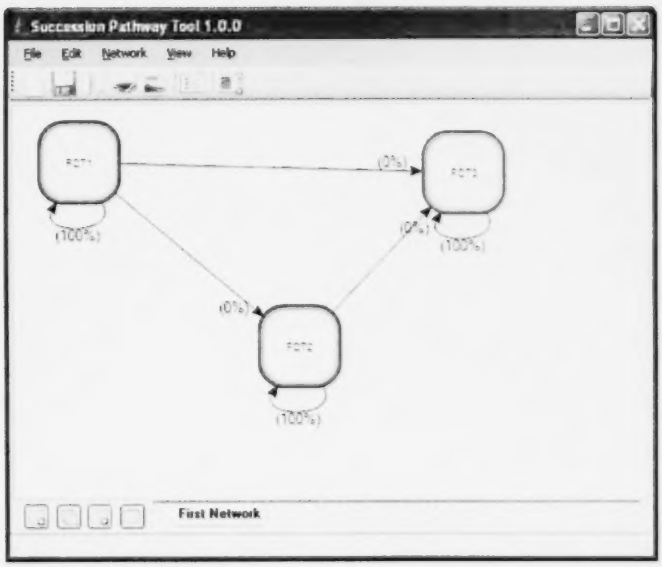




6. To create succession pathways within the network, select and hold the left mouse button, moving it from just inside node FCT1 and dragging it to FCT2. This will result in a line (link) between the two nodes – this is a succession pathway from FCT1 to FCT2. (Note that since all the probabilities are set to 0 (default), no proportional changes are indicated yet.)

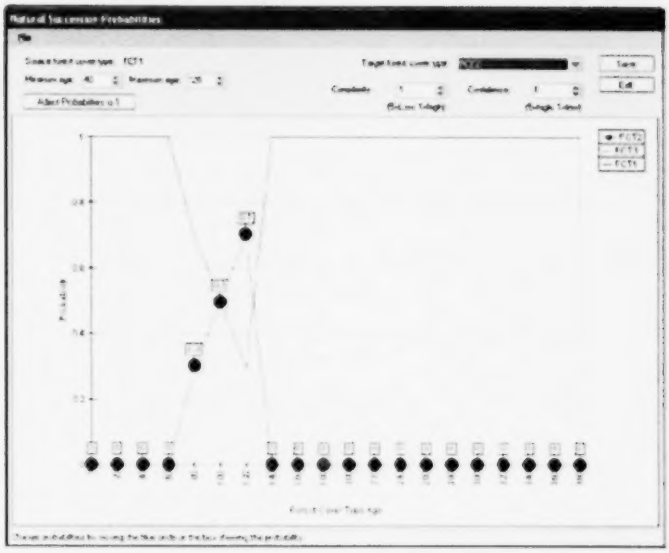


To make a succession pathway, select just inside the shape. To move the node, select the centre of the shape.



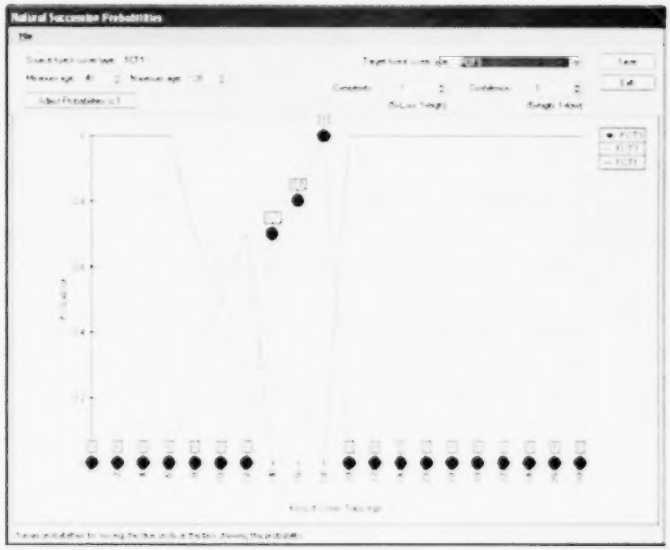
7. Use the same approach to make another succession pathway between FCT1 and FCT3.
8. Finally, make another succession pathway between FCT2 and FCT3. Your window should look similar to that shown at right.

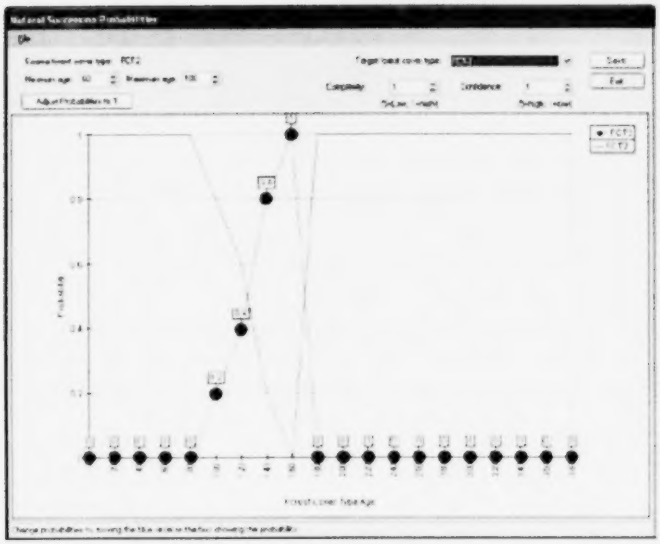
9. After the succession pathways have been created, probabilities are entered for those pathways. Double clicking the FCT1 node will display the *Natural Succession Probabilities* window.
10. In the *Natural Succession Probabilities* window, enter probabilities for the succession pathway from FCT1 to FCT2. Probabilities can be changed by using the mouse to move the blue dots or the boxes that display the probability value.



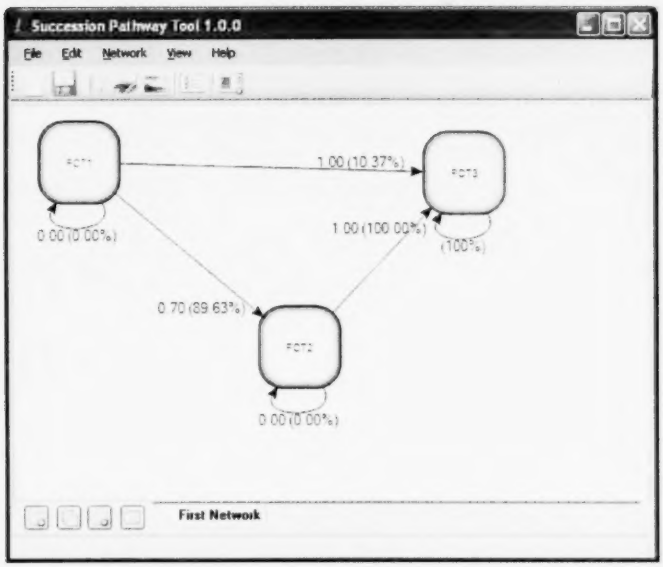
Note that the source forest cover type probabilities are adjusted automatically so that the sum of the probabilities for a time step remains equal to 1.

11. Next change the *Target forest cover type* drop down box to FCT3 and enter the probabilities for the succession pathway from FCT1 to FCT3. Select *Save* to save the pathways and return to the network window.





12. Next enter probabilities for the succession pathway from FCT2 to FCT3 by double clicking the FCT2 node and entering the appropriate values. Select *Save* to close the window.



13. The network window now displays the additional information about the succession pathways.

    In this case, the results indicate that both FTC1 and FTC2 will succeed to FCT3 and FCT3 will undergo self-replacement.

14. To save the changes to the succession pathway file, select the *Save* button or *File, Save* on the menu bar.

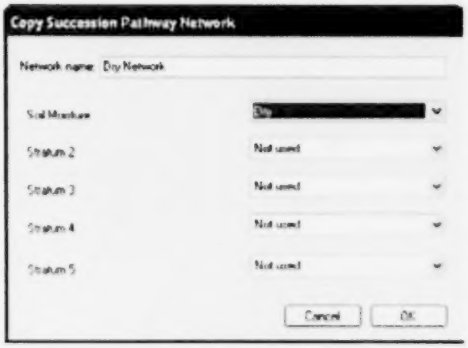
In this step, a very simple succession pathway network was created that includes three succession pathways. Note that this is a very simple succession pathway network. It is possible, however, to use SPT to create networks with dozens of forest cover type nodes and many dozens of succession pathways.

Note *The file containing Step 2,* Example Natural Succession Step 2 Completed.pt, *is available in the Succession Pathway Tool installation folder.*

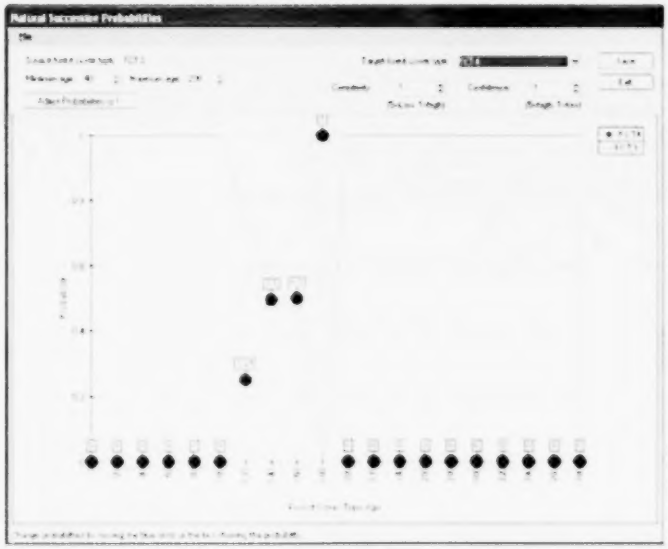
Step 3: Creating the Second Succession Pathway Network

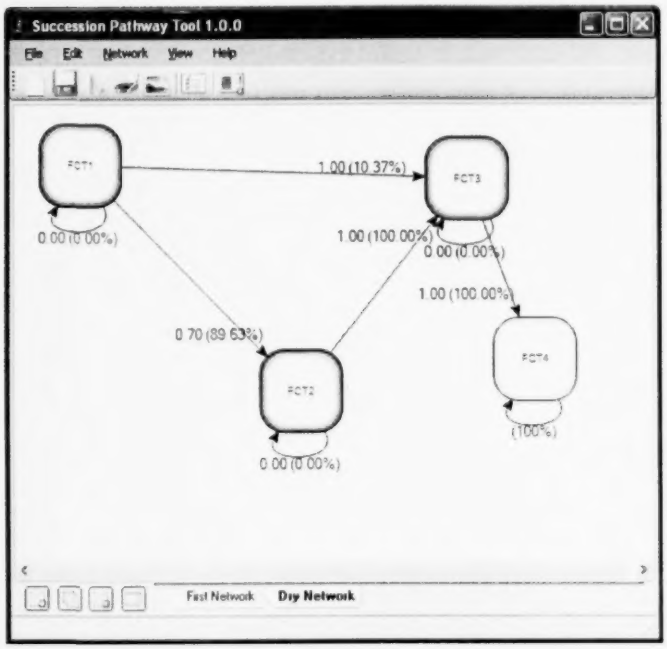
Here we describe the steps involved in creating a new succession pathway network based on an existing network. This strategy saves time when a new network is similar to an existing network.

1. Select the *Copy Network* button on the lower left of the main application window or select *Network/Copy* option on the menu bar to show the *Copy Succession Pathway Network* window.
2. In the window enter *Dry Network* for the *Network name*.
3. Select *Dry* in the drop down for *Soil Moisture* (previously stratum 1) (see right).
4. Select *OK* in the *Copy Succession Pathway Network* window. This will create a new network in the main window with succession pathways that are identical to those in the network created in Step 2.



5. To add a new forest cover type to this new network, right-click on the window and select the *Forest Cover Type / FCT4* option to include the forest cover type named FCT4 in the network.
6. Place the FCT4 node in the window so that it does not overlap with any other nodes by selecting the centre of the node and moving it to a new location.
7. Create a succession pathway by selecting the inside edge of the FCT3 node and linking it to the FCT4 node.
8. Double click on the FCT3 node to display the *Natural Succession Probabilities* window. Enter the values to match the example shown by dragging the blue dots or the probability value boxes.





9. When all the probabilities are entered, select *Save* to close the active window.

   The display should look similar to window shown.

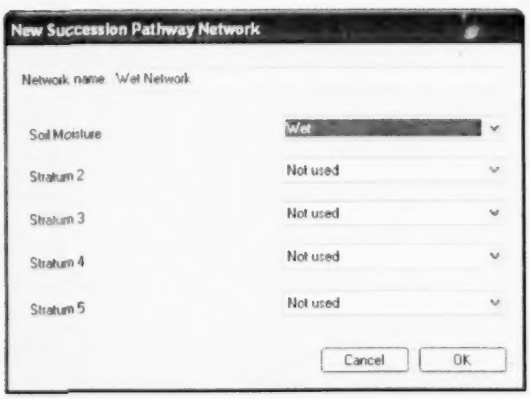
To save the succession pathway file, select *Save* on the toolbar.

This step is now complete: a new succession pathway network was created based on an existing network and subsequently modified.

Note *The file containing Step 3,* Example Natural Succession Step 3 Completed.pt, *is available in the Succession Pathway Tool installation folder.*

Step 4. Creating a Third Succession Pathway Network

In this step, we describe how to create a succession pathway network based on two forest cover types.



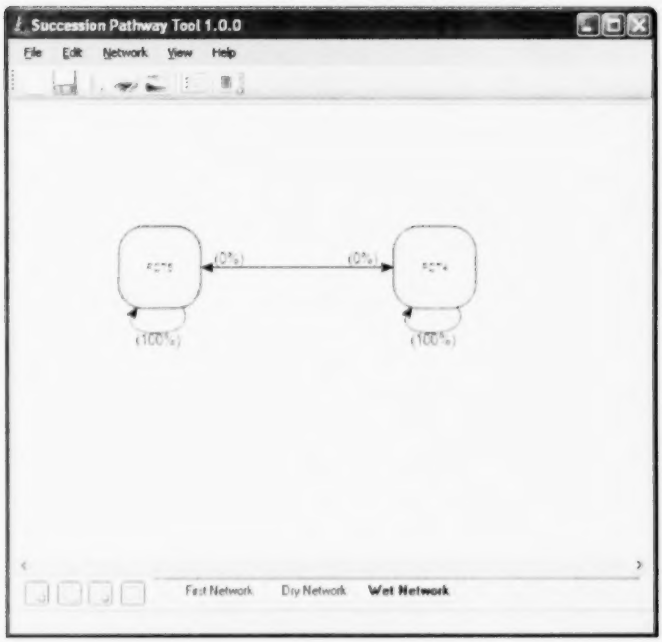
1. Select *New Network* button or *Network, New* option on the menu bar to display the *New Succession Pathway Network* window.
2. Enter *Wet Network* as *Network name.*
3. Select *Wet* option from the drop down menu beside *Soil Moisture* (previously stratum 1) and select *OK.*

4. Selecting *OK* will display the *Insert Forest Cover Types* window. Highlight the last two forest cover types in the list (FCT4 and FCT5) and select *OK*.

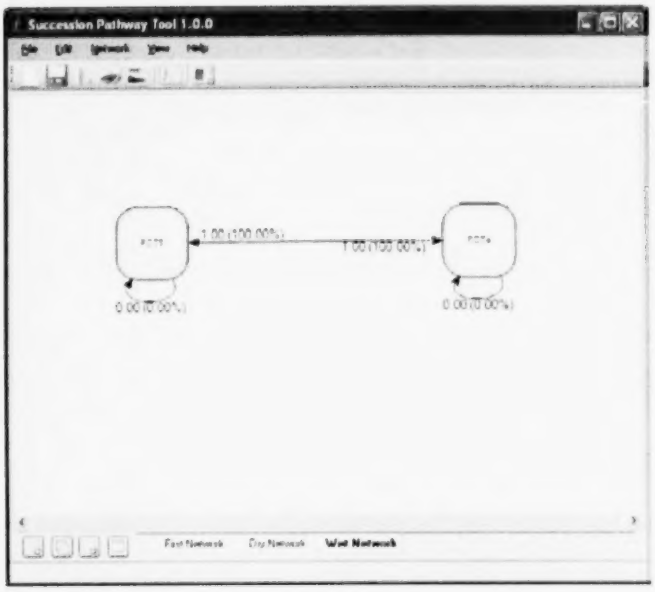
   This will result in a new window displaying the selected forest cover types as nodes.

5. Select and hold the left mouse button in the middle of a node to move it to where it does not overlap with another node.
6. To create a succession pathway from FCT4 to FCT5, select the FCT4 node, hold the left mouse button, and drag the cursor from just inside FCT4 to FCT5.
7. To create a succession pathway from FCT5 to FCT4, select the FCT5 node, hold the left mouse button, and drag the cursor from just inside the node from FCT5 to FCT4.

   The window should now look similar to that shown.



8. After the succession pathways have been created, probabilities are entered. Double click the FCT4 node to display the *Natural Succession Probabilities* window.
9. In the *Natural Succession Probabilities window*, enter a probability of succession of 1 for the succession pathway from FCT4 to FCT5 at age 100.
10. Select *Save* to save the pathways and return to the network window.
11. Double click the FCT5 node to display the *Natural Succession Probabilities* window.
12. In the *Natural Succession Probabilities window*, enter a probability of succession of 1 for the succession pathway from FCT5 to FCT4 at age 120.

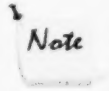


13. Select *Save* to save the pathways and return to the network window.

    The network window will be updated with the specified probabilities and associated proportional changes and should look similar to that shown.

14. Select *Save* button or *File, Save* on the menu bar to save the changes to the succession pathway file.

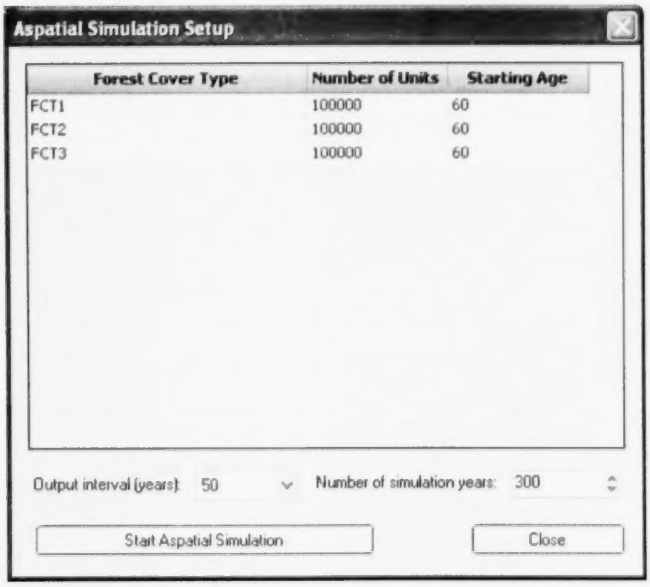
In this step, a simple succession pathway network was created for another stratum. This network alternates between two forest cover types over time as they undergo succession.



The file containing Step 4, Example Natural Succession Step 4 Completed.pt, is available in the Succession Pathway Tool installation folder.

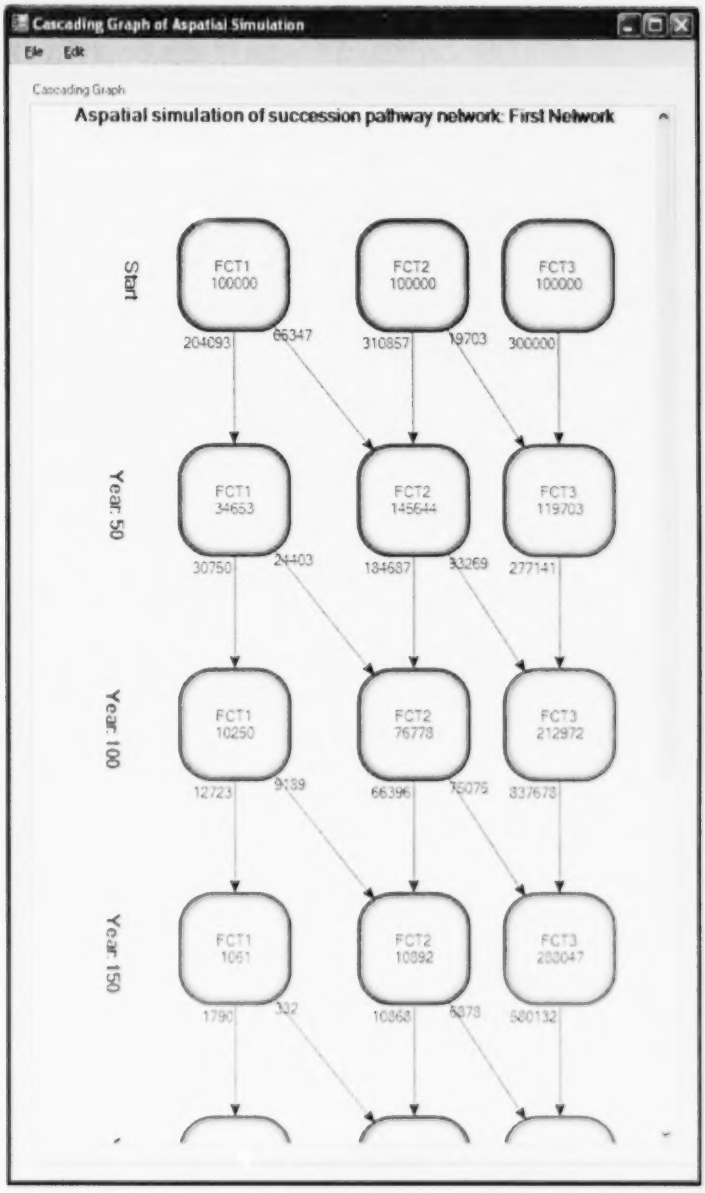
Step 5: Simulation of a Succession Pathway Network

Here we describe the use of the succession pathway network created in *Step 2* to run simulations.



1. From the tabs at the bottom of the network window select the succession pathway network called *First Network*.
2. Select *View / Aspatial Simulation* on the menu bar or the *Aspatial Simulation* button on the toolbar.
3. In the *Aspatial Simulation Setup* window change the values for the *Starting age* for all three forest cover types to 60. This is the age used to initialize the forest cover type age.
4. Set the simulation *Output interval* to 50 years
5. Set the *Number of simulation years* to 300. The window should look similar to that shown.

6. Select the *Start Aspatial Simulation* button. Depending on computer resources, the simulation should take less than a minute but it may take longer when the number of units is high.
7. Simulation results are shown at right. Note that because SPT uses probabilities, simulation results for a given network are unlikely to be identical, but they will follow the same pattern.

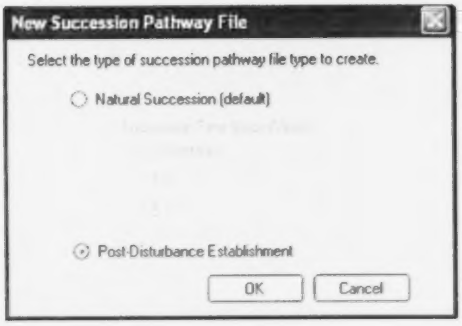


3.2 Post-Disturbance Establishment Example

In this section, we illustrate the use of the succession pathway tool (SPT) to create a succession pathway file for two post-disturbance establishment succession pathway networks.

Step 1: Creating a Succession Pathway File and Setting up the Parameters

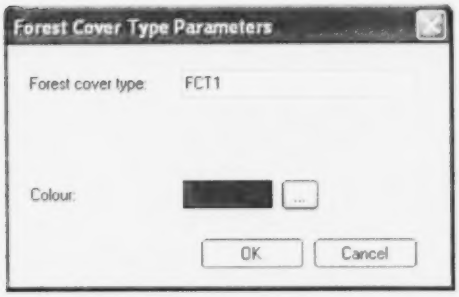
The process for creating a post-disturbance establishment succession pathway file and setting up forest cover type and strata parameters needed to create post-disturbance establishment succession pathways is as follows:



1. Start SPT.
2. Select *File, New* on the menu bar or the *New* button on the toolbar.
3. In the *New Succession Pathway File* window, select *Post-Disturbance Establishment* and select *OK*.
4. Selecting *OK* will display the *Succession Pathway File Settings* window.

Forest Cover Type	Colour
FCT1	Red
FCT2	Green
FCT3	Blue
FCT4	Yellow
FCT5	Grey

5. First, add forest cover types. For these examples, five forest cover types (FCTs 1-5) will be used as shown in the table at left.
6. Select *Add* button at the bottom of the window to display the *Forest Cover Type Parameters* window.
7. Enter *FCT1* in the *Forest Cover Type* field in the window.



8. Set the colour to red using the button or by double clicking on the coloured square.
9. Select *OK* to finish adding the forest cover type parameters and close the window.

10. Enter the remaining four forest cover types and their parameters (repeat steps 5 to 9 using the names and colours shown in the example).

    The resulting window should match the example shown.

Alternatively, pre-defined lists of forest cover types can be imported using the *Import* option (see section 2.1.1 for details).

11. To enter the stratum information, select the tab labelled *Stratum 1*.

12. Enter *Soil Moisture* as the stratum name in the *Stratifying criteria* field.

13. Select *Add* and enter *Wet* in the popup window.

14. Select *Add* and enter *Dry* in the popup window. The window should match the example shown.

    Alternatively, pre-defined lists of strata can be imported using the *Import* option (see section 2.1.2 for details).

15. Select the tab labelled *Stratum 2*.

16. Enter *Soil Nutrients* as the stratum name in the *Stratifying criteria* field.

17. Select *Add* and enter *Poor* in the popup window.

18. Select *Add* and enter *Rich* in the popup window. The window should match the example shown.

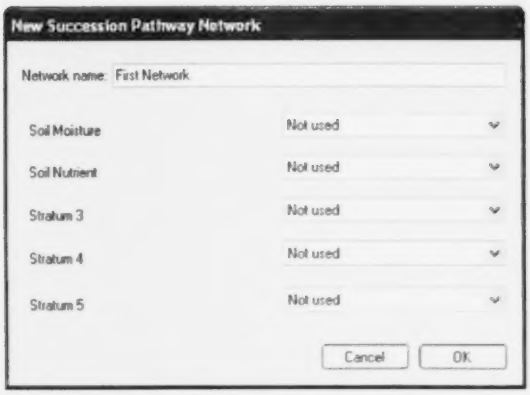
19. Select C*lose* to exit the *Succession Pathway File Settings* window and return to the main application. A prompt to save the file will display. Selecting *Yes* will display a *File Save As* window. Alternatively, the file can be saved by selecting the *Save* icon on the toolbar or selecting the *File, Save as* on the menu bar to save to a new file.

This completes the configuration of the succession pathway file, which can now be used to create post-disturbance establishment succession pathway networks.

Note *The file containing Step 1, Example Post Disturbance Step 1 Completed pt, is available in the Succession Pathway Tool installation folder.*

Step 2: Creating the First Succession Pathway Network

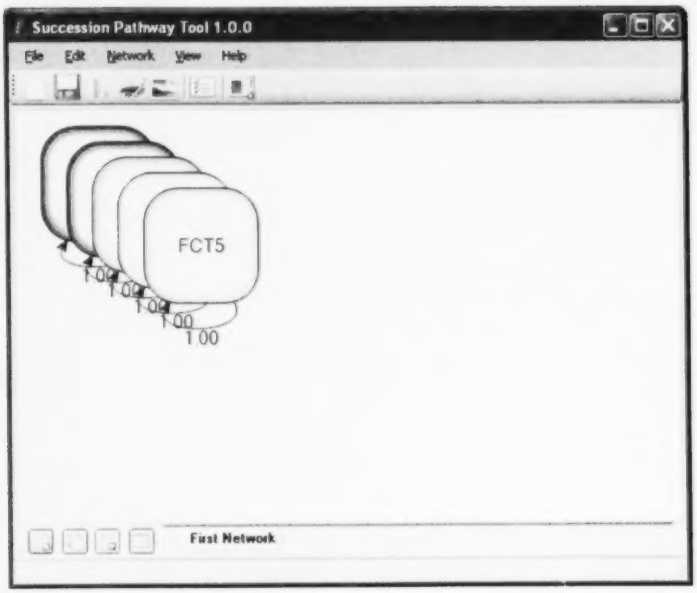
Here we outline the steps to create the first post-disturbance establishment succession pathway network in this succession pathway file. The network will be created at the most basic level, that is, it does not use stratum information.



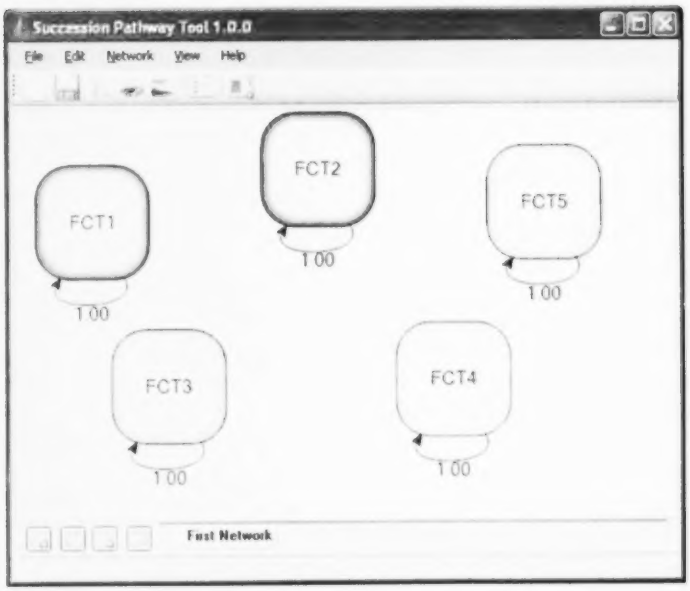
1. Select *Network/New* on the menu bar or the *New Network* button on the bottom left in the window.
2. For the *Network Name* enter "First Network" and select *OK*. Since stratum information is not being used for this succession pathway network, none of the other options on this window apply.

3. Selecting *OK* will display the *Insert Forest Cover Types* window. Choose *Select all* to include all the forest cover types and select *OK*.

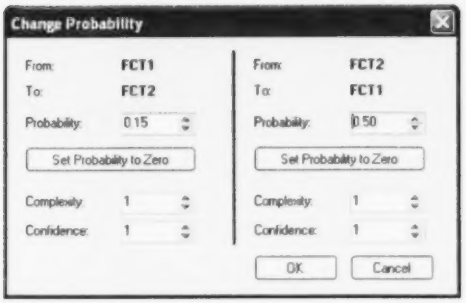
4. A new window will display showing the selected forest cover types as a series of nodes.



5. Select and hold the left mouse button on the middle of each node to move them so as not to overlap with other nodes. The nodes should now be positioned similar to those shown in the example.



6. To create succession pathways within the network, select a node, hold the left mouse button, and move it from just inside the node to another node. This will result in a pathway (link) between the two nodes – this creates a succession pathway. Create a pathway between FCT1 and FCT2.

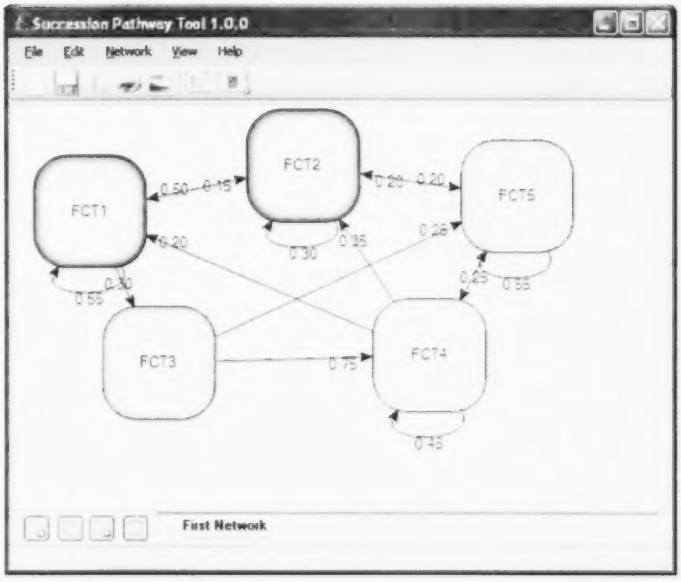


7. After the pathway is created, the *Change Probability* window will display. Set the probability of FCT2 establishing after FCT1 is disturbed (i.e., FCT1succeeding to FCT2) to 0.15 using the up and down arrows (or enter values in text box). Then set the probability of FCT2 succeeding to FCT1 to 0.5. Select *OK* to close the window and return to the network.

Note *The complexity and confidence for each pathway can also be set in the Change Probability window.*

8. Enter the values from the following table to complete the network (by repeating steps 6 and 7).

From	To	Probability Value
FCT1	FCT3	0.30
FCT2	FCT5	0.20
FCT3	FCT4	0.75
FCT3	FCT5	0.25
FCT4	FCT1	0.20
FCT4	FCT2	0.35
FCT5	FCT4	0.25
FCT5	FCT2	0.20



9. After all the pathways are entered, the network window should resemble the example shown.

This completes the steps to create the first post-disturbance establishment succession pathway network.

Note *The file containing Step 2, Example Post Disturbance Step 2 Completed.pt, is available in the Succession Pathway Tool installation folder.*

Step 3: Creating the Second Succession Pathway Network

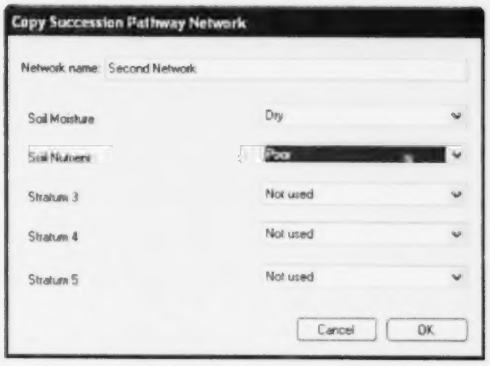
Here we describe the steps involved in creating a new succession pathway network based on an existing network. This strategy saves time when a new network is similar to an existing network. This new network will use strata information but will not include FCT2.

1. Select *Copy Network* in the bottom left corner of the window or select *Network/Copy* on the menu bar.

2. In the window enter *Second Network* for the *Network name*.

3. Select *Dry* from the drop down box for *Soil Moisture* (previously Stratum 1).

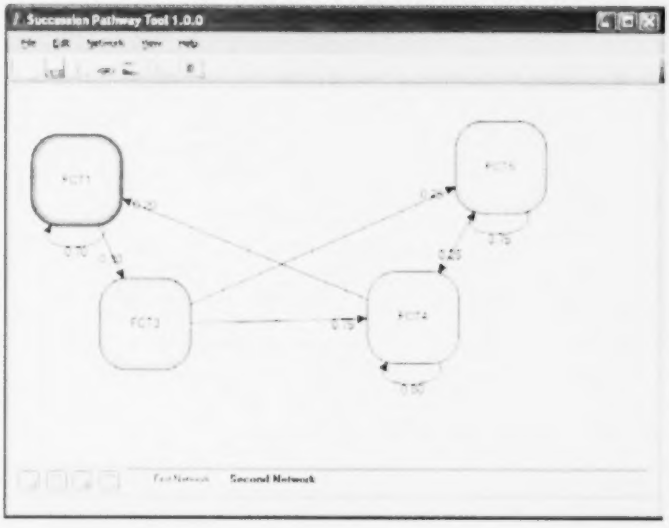
4. Select *Poor* from the drop down box for *Soil Nutrient* (previously Stratum 2) (see right).



5. Select *OK* in the *Copy Succession Pathway Network* window. This will create a new network in the main window with succession pathways that are identical to those in the network created in Step 2.

6. All the pathways in the network can be modified simultaneously by deleting FCT2 from the network.

   SPT will adjust all probabilities automatically by adding the probability of the deleted pathways to the self-replacement probabilities (see example).

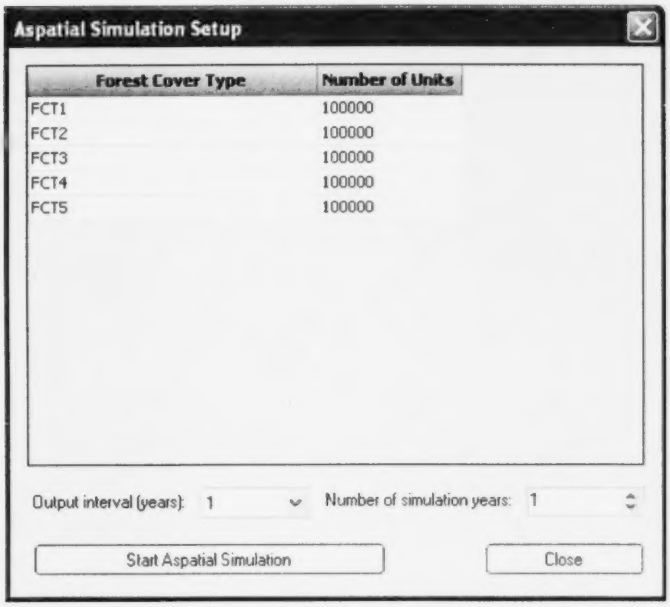


A good strategy is to initially create a generic succession pathway network that does not use any strata information. By copying this generic network to more specific strata combinations and editing it, information about the effects of environmental conditions can be quickly added to the networks, for example, by adding/removing succession pathways or adding/removing forest cover types.

Note *The file containing Step 3, Example Post Disturbance Step 3 Completed.pt, is available in the Succession Pathway Tool installation folder.*

Step 4: Simulating the Succession Pathway Network

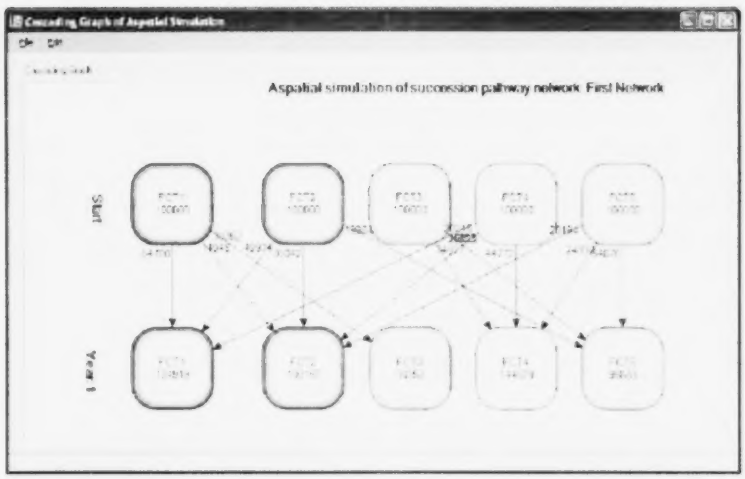
Here we describe how to use the succession pathway network created in Step 2 to run simulations.



1. From the tabs at the bottom of the network window, select the succession pathway network called *First Network*.

2. Select *View/Aspatial Simulation* on the menu bar or the *Aspatial Simulation* button on the toolbar.

3. In the *Aspatial Simulation Setup* window, enter the number of hectares for each forest cover type. Here we used the default value of 100,000 units (see example shown). Select the *Start Aspatial Simulation* button.



4. The simulation results will display as a graph similar to the example shown.

   Aspatial simulation results for post-disturbance establishment networks are simpler than those for natural succession because only one simulation step is involved.

   Select the links between nodes will display the value associated with that link in the status bar.

Note *Note that because the simulations are probabilistic, simulation results for a given network are unlikely to be identical but will follow the same pattern.*

References

Drescher, M. and A.H. Perera. 2010a. Comparing two sets of forest cover change knowledge used in forest landscape management planning. Journal of Environmental Planning and Management. in press

Drescher, M. and A.H. Perera. 2010b. A network approach for evaluating and communicating forest change models. Journal of Applied Ecology. doi: 10.1111/j.1365-2664.2009.01754.x

Drescher, M., A.H. Perera, L.J. Buse, K. Ride and S. Vasiliauskas. 2006. Identifying uncertainty in practitioner knowledge of boreal forest succession in Ontario through a workshop approach. Ontario Ministry of Natural Resources, Ontario Forest Research Institute, Sault Ste Marie, ON. Forest Research Report 165. 53 p.

Drescher, M., Perera, A.H., Buse, L.J., Ride, K., and Vasiliauskas, S. 2008. Uncertainty in expert knowledge of forest succession: A case study from boreal Ontario. The Forestry Chronicle 84 (2): 194-209.

[MSRM] Ministry of Sustainable Resource Management. 2004. Resource Analysis Guide for Sustainable Resource Management Planning. Volume 1. Government of British Columbia, Victoria, BC. [http://ilmbwww.gov.bc.ca/lup/srmp/background/rag.html; accessed October 26, 2008]

[OMNR] Ontario Ministry of Natural Resources. 2004. Forest Management Planning Manual for Ontario's Crown Forests. Ontario Ministry of Natural Resources. Toronto, ON.

Oullette, M. 2008. BFOLDS 1.0: A user's guide to the software package (Version 1.0.0). Ontario Ministry of Natural Resources, Ontario Forest Research Institute, Sault Ste. Marie, ON. Forest Research Information Paper No. 171. 68 p

Perera, A.H., M. Ouellette, W. Cui, M. Drescher and D. Boychuk. 2008. BFOLDS 1.0: A spatial simulation model for exploring large scale fire regimes and succession in boreal forest landscapes. Ontario Ministry of Natural Resources, Ontario Forest Research Institute, Sault Ste. Marie, ON. Forest Research Report 152. 50 p.

Shifley, S.R., F.R. III Thompson, D.R. Larsen, W.D. Dijak, M.A. Larson and J.J. Millspaugh. 2000. Modeling forest landscape change in the Missouri Ozarks under alternative management practices. Computers and Electronics in Agriculture 27: 7-24.

[USDA] USDA Forest Service. 1996. Timber Resource Planning Handbook. USDA Forest Service, Washington, DC. Forest Service Handbook 2409.13. [http://www.fs.fed.us/cgi-bin/Directives/get_dirs/fsh?2409.13!; accessed April 16, 2008]

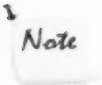
Appendix 1. Using the *Succession Pathway Tool* with BFOLDS

BFOLDS users can take advantage of the *Succession Pathway Tool* (SPT) to create and/or edit their succession pathways. Differences between BFOLDS and the SPT tool to be aware of include use of terms and certain limitations as outlined in the table below.

Attribute	BFOLDS convention	Succession Pathway Tool convention
Stratum designations	Zone Site Factor 1 Site Factor 2 Site Factor 3 Site Factor 4	Stratum 1 Stratum 2 Stratum 3 Stratum 4 Stratum 5
Number of forest cover types	Maximum of 30	Limited only by system resources
Number of strata	Maximum of 9 classes per zone Maximum of 5 classes per site factor	Limited only by system resources
Age terminology	Incoming age	Minimum age

When building forest cover type and strata lists for BFOLDS, the limits indicated in the above table must not be exceeded. The recommended approach to ensuring that forest succession network information is compatible with BFOLDS is to:

- Create the strata and forest cover type classes using the BFOLDS Toolbox (see Ouellette 2008)
- Apply the *File/BFOLDS/Import BFOLDS Study Settings* to import the forest cover types, zone, and site factor information from a BFOLDS study and convert it to the SPT format.



Note that this will not import any existing succession rules from the BFOLDS study.

Once forest cover type and strata information have been imported or created, succession networks and pathways can be created as outlined in this guide. After the pathways have been edited, the appropriate export option, under *File/BFOLDS* on the menu bar, is used to export the natural succession, post-disturbance establishment, or canopy ageing rules for BFOLDS.

Appendix 2. Installing and Activating the *Succession Pathway Tool*

Hardware requirements

The Succession Pathway Tool (version 1.0) will work on any computer with a processor running at 1 gigahertz or higher. The main requirement of the tool is computer memory: Less than 512MB RAM will slow the network visualizations and the aspatial simulations.

The **minimum** recommended computer specifications are:

- Dual Core system running at 1 gigahertz or higher
- 1 Gigabyte of RAM
- 20 megabytes of available disk space
- Mouse or other pointing device
- Display resolution of 1280 by 1024 pixels or higher

Software requirements

Operating system:

- Windows XP Service Pack 2 or newer versions of Windows

Other required software:

- Microsoft .NET framework version 2.0 or higher

Installation instructions

Installing *Succession Pathway Tool 1.0* is similar to installing any other Windows application:

- After downloading and extracting the zip file (available at http://www.flep.ca/software/sptool.aspx), run the setup.exe file.

Note *Install updates only when the* Succession Pathway Tool *is not running.*

Starting and activating *Succession Pathway Tool 1.0*

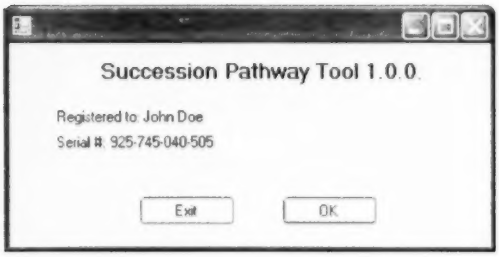
The Succession Pathway Tool (SPT) software has an activation feature that is linked to the user's computer. This helps the developers to ensure that users receive information about updates and timely technical support.

Activating the software

To activate the SPT, the user must:

1. Select the *Succession Pathway Tool* shortcut in the *Start* menu to open a registration window.
2. Use the activation dialog box to send an e-mail to flep@ ontario.ca that includes the user name and the machine (i.e., computer) name.
3. Select the *Exit* button to close *Activation* window.
4. Following receipt of registration response e-mail (usually sent within 24 hours, Monday to Friday) start SPT again and enter:
   i. User name, exactly as typed in the e-mail
   ii. User e-mail address
   iii. Serial number provided in the reply e-mail
5. Select the *Activate* button.

If the activation information is entered correctly, *Succession Pathway Tool 1.0* is registered on that computer and this step need not be repeated.



The next time the tool is started, a registration window (see example left) will display, followed by the main SPT window.

Appendix 3. Using Strata Information

In the Succession Pathway Tool (SPT), the use of strata is optional. Generic succession pathway networks that do not include strata (such as that presented in Section 3.1, Step 2) can be used for example when strata information is unknown or when the user wants a particular network to apply to the entire study area.

However, defining strata allows the user to create much more specific networks that incorporate local knowledge. Strata are hierarchical, that is, they are nested within one another. To create a succession pathway network that uses a lower level stratum, the strata above it must be defined (set to a value other than the default – *not used*). As well, while SPT is not spatial per se, strata can be used to add a spatial element.

Figure A illustrates an example of the possible configuration of strata for a hypothetical network. In this example, three strata are defined: location, soil moisture regime, and soil nutrient regime. Within each of these strata, classes are defined; in this case, A, B, and C for location; wet and dry for soil moisture regime, and poor and rich for soil nutrient regime.

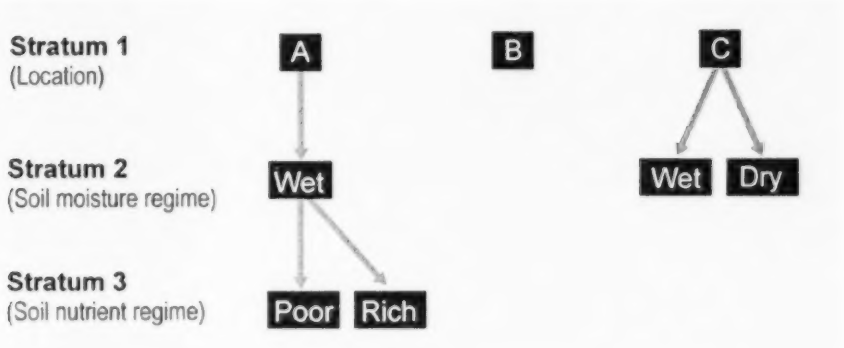


Figure A. *Example of how strata can be applied in the succession pathway tool.*

Incorporating location allows users to create additional networks with information specific to those areas, making the succession pathway networks geographically specific.

If knowledge about successional differences among soil moisture regimes is available, as indicated for location class C in Figure A, two additional succession networks can be created for those specific cases. Note that not all classes defined for a stratum need to be used in every case. For example, for location class A in Figure A only the wet soil moisture class is used.

For location class A, a third strata is used to add information about soil nutrients. Specific succession pathway networks can then be defined for poor and rich site conditions within wet sites for that area.

In this example only three strata were used but up to five can be defined, each of which can contain an unlimited number of classes.

Note

If a higher-level stratum class, such as A in the example in Figure A, is removed from the succession pathway file, then all lower-level strata combinations that include this class also will be removed.

Appendix 4. Importing and Exporting Networks

Networks created in the Succession Pathway Tool (SPT) can be exported for use or modification in other programs. This is possible using the *Copy Matrix* and *Paste Matrix* options under *Edit on the* menu bar.

Networks can be exported as matrices from the tool to programs, such as Microsoft Excel, that use a clipboard and are compatible with ASCII data. However, if the intention is to re-import the matrix into the tool, any modifications need to be done carefully.

To import a modified matrix into the tool, the following requirements must be met:

- Number of columns must match the exported data
- Number of rows must match the exported data
- Probabilities within rows must equal 1 or 0
- Column headings must be identical to the exported data
- Row headings must be identical to the exported data
- The succession year must stay the same (not relevant for post-disturbance establishment networks)
- The column delimiter must be a tab (Microsoft Excel default)

As well, succession networks from other sources can be imported into SPT given that the format is compatible.

The tables below provide examples of a natural succession matrix and a post-disturbance establishment matrix. The format of the matrices is identical except that the natural succession matrix has an extra column labelled *Time* for the succession year. In the matrices below, the forest cover types used are referred to as a, b, c, and d. In actual data files, these would be replaced by the designations entered in the *Succession Pathway File Settings*.

Example of a natural succession data matrix:

Time		A	B	C	D
0	A	1	0	0	0
0	B	0	1	0	0
0	C	0	0	1	0
0	D	0	0	0	0
20	A	1	0	0	0
20	B	0	1	0	0
20	C	0	0	1	0
20	D	0	0	0	0
40	A	0	0.5	0.5	0
40	B	0	1	0	0
40	C	0	1	0	0
40	D	0	0	0	0
60	A	1	0	0	0
60	B	0	1	0	0
60	C	0	0	1	0
60	D	0	0	0	0
80	A	1	0	0	0
80	B	0	1	0	0
80	C	0	0	1	0
80	D	0	0	0	0
100	A	1	0	0	0
100	B	0	1	0	0
100	C	0	0	1	0
100	D	0	0	0	0
120	A	1	0	0	0
120	B	0	1	0	0
120	C	0	0	1	0
120	D	0	0	0	0
140	A	1	0	0	0
140	B	0	1	0	0

140	C	0	0	1	0
140	D	0	0	0	0
160	A	1	0	0	0
160	B	0	1	0	0
160	C	0	0	1	0
160	D	0	0	0	0
180	A	1	0	0	0
180	B	0	1	0	0
180	C	0	0	1	0
180	D	0	0	0	0
200	A	1	0	0	0
200	B	0	1	0	0
200	C	0	0	1	0
200	D	0	0	0	0
220	A	1	0	0	0
220	B	0	1	0	0
220	C	0	0	1	0
220	D	0	0	0	0
240	A	1	0	0	0
240	B	0	1	0	0
240	C	0	0	1	0
240	D	0	0	0	0
260	A	1	0	0	0
260	B	0	1	0	0
260	C	0	0	1	0
260	D	0	0	0	0
280	A	1	0	0	0
280	B	0	1	0	0
280	C	0	0	1	0
280	D	0	0	0	0
300	A	1	0	0	0
300	B	0	1	0	0
300	C	0	0	1	0
300	D	0	0	0	0
320	A	1	0	0	0
320	B	0	1	0	0
320	C	0	0	1	0
320	D	0	0	0	0
340	A	1	0	0	0
340	B	0	1	0	0
340	C	0	0	1	0
340	D	0	0	0	0
360	A	1	0	0	0
360	B	0	1	0	0
360	C	0	0	1	0
360	D	0	0	0	0
380	A	1	0	0	0
380	B	0	1	0	0
380	C	0	0	1	0
380	D	0	0	0	0

Example of a post-disturbance establishment data matrix:

	A	B	C	D
A	0.1	0.7	0	0.2
B	0	1	0	0
C	0	0	1	0
D	0.25	0	0	0.75

52611
(0.3k P.R., 10 01 30)
ISSN 0319-9118 (print)
ISBN 978-1-4435-1893-2 (print)
ISBN 978-1-4435-1894-9 (pdf)